



A Report Prepared for:

Univar USA Inc.
3950 NW Yeon Avenue
Portland, Oregon

**FINAL DRAFT
CORRECTIVE MEASURES STUDY REPORT
UNIVAR USA INC.
PORTLAND, OREGON**

VOLUME 1

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ABBREVIATIONS

1,1,1-TCA	1,1,1-trichloroethane
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1,2-DCE	1,2-dichloroethene
AL	action level
AOC	Administrative Order on Consent
AS	air sparging
bgs	below ground surface
CAA	corrective action alternative
CAO	corrective action objective
cfm	cubic feet per minute
CMS Work Plan	Final Corrective Measures Study Work Plan
CMS	corrective measures study
COC	chemical of concern
COPC	chemicals of potential concern
CUL	cleanup levels
CY	cubic yards
DEQ	Department of Environmental Quality
DNAPL	dense nonaqueous phase liquid
EPA	U.S. Environmental Protection Agency
FOD	frequency of detection
ft/day	feet per day
ft/ft	feet per foot
ft/yr	feet per year
gpm	gallons per minute
HEA	Health and Environmental Assessment
HI	hazard index

HLA	Harding Lawson Associates
ICM	interim corrective measures
ITC	IT Corporation
JEM	Johnson and Ettinger Model
lbs/day	pounds per day
lbs/yr	pounds per year
MC	methylene chloride
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MNA	monitored natural attenuation
MPS	minimum protection standards
NAPL	nonaqueous-phase liquids
NPDES	National Pollution Discharge Elimination System
NPV	net present value
PCE	tetrachloroethene or perchloroethylene
PES	PES Environmental Inc.
ppmv	parts per million by volume
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation Report
ROI	radius of influence
SL	screening level
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TCE	trichloroethene
tHBL	total health-based level
UV	ultraviolet
Univar	Univar USA Inc.
VC	vinyl chloride
VOC	volatile organic compound
Vopak	Vopak USA Inc.
VW&R	Van Waters & Rogers Inc.

EXECUTIVE SUMMARY

Background

This report documents the findings of the corrective measures study (CMS) conducted by PES Environmental, Inc. (PES) for the Univar USA Inc. (Univar) facility in Portland, Oregon. The overall objective of the CMS process is to develop and evaluate corrective action alternatives (CAAs) to address the contaminant releases identified at the site. To achieve this objective, the CMS was conducted consistent with the following documents:

- RCRA Corrective Action Plan (Final) - OSWER Directive 9902.3-2A (EPA, 1994);
- Final Corrective Measures Study Work Plan (CMS Work Plan; HLA, 1994); and
- Revised CMS Workplan Addendum No. 1 (EMCON, 1997a).

These work plans were prepared, as required by the U.S. Environmental Protection Agency Region 10 (EPA), consistent with the provisions of the Administrative Order on Consent (AOC) dated June 15, 1988 (EPA, 1988). The AOC was issued by EPA pursuant to Section 3008(h) of RCRA. The provisions and requirements of the AOC, along with other relevant RCRA regulations and guidance, provided the basis for all environmental activities at the facility including site investigation activities, interim corrective measures (ICMs), and the performance of this CMS.

Site Description

Facility Activities. Since 1947, Univar has conducted bulk chemical handling and storage at the 9.5 acre facility, located in the heavily industrialized area northwest of downtown Portland. Bulk chemicals were stored in 13 underground storage tanks, all of which were removed in 1985. At the time of removal, the tanks were tested and found to be tight. No soil sampling was conducted as part of the removal.

Univar began the recycling of spent chlorinated solvents in 1973, together with the storage of certain hazardous wastes associated with the recycling facility. The recycling and storage of associated hazardous waste were suspended in 1987. The hazardous wastes storage facility underwent procedural closure under Section 3008(a) of RCRA in 1988.

Four chemical releases at the facility were reported between 1979 and 1985. These included a trichloroethene (TCE) release immediately south of the former recycling area, a release of a blend of methylene chloride (MC) and toluene adjacent to the loading dock near the drum fill area, an MC release adjacent to the loading dock south of the drum fill area, and a mineral acid release on the east side of the facility northeast of the fill shed. Additional chemicals present in soil and groundwater have been characterized and will be included as part of the CMS.

Site Geology and Hydrogeology. The Univar facility is located on the Willamette River floodplain approximately 2,200 feet south of the river and 1,000 feet north and northeast of the Tualatin Mountains. The floodplain near the facility is underlain by artificial fill, Quaternary alluvial and lacustrine deposits, the Pliocene Troutdale Formation, and Tertiary Columbia River Basalts (from youngest to oldest). The shallowest aquifer in the area consists of Quaternary alluvial and lacustrine deposits. Based on site characterization investigations performed at industrial facilities in the area, depth to groundwater ranges from less than 10 feet to 20 feet below ground surface (bgs) with variable groundwater flow directions.

Six geologic units have been identified beneath the facility:

- Grade fill, found from the surface to a depth of 5 feet;
- Dredged sand, silt, and clay, found between 1 and 32 feet bgs, ranging in thickness from about 13 to 31 feet; the lower sandy portion constitutes the shallow aquifer and is found between 2 and 32 feet bgs, ranging up to 29 feet thick (pinching out to the east and southwest);
- Alluvial and lacustrine silt and clay (intermediate aquitard), found between 14 and 75 feet bgs, ranging in thickness from approximately 28 to at least 45 feet;
- Alluvial gravel and sand (lower aquifer), found between 57 and 94 feet bgs, ranging in thickness from about 5 to 14 feet;
- Clay, silt, and sandy silt; found between 63 feet and 100 feet bgs in portions of the site; and
- Weathered bedrock consisting of siltstone and sandstone, encountered below depths of at least 94 feet bgs.

Approximate depth to groundwater in the shallow aquifer ranges from 6 to 13.8 feet bgs. Shallow aquifer groundwater elevations range from approximately 22.8 to 28.5 feet above the City of Portland datum. In monitoring wells completed in the deep aquifer and transitional silty sand interbeds at the base of the aquitard, approximate depth to groundwater ranges from 7 to 17 feet bgs. Deeper groundwater elevations range from 19.7 to 27.5 feet above the City of Portland datum. Groundwater in the shallow aquifer flows toward the site from the west and splits into southerly and northerly flow beneath

the site. The average linear groundwater velocity in the shallow aquifer is estimated to range from less than 550 ft/yr to 1,150 ft/yr. The vertical groundwater velocity across the aquitard is estimated to be 0.42 ft/yr. Groundwater flow in the deep gravel aquifer is variable with the most common flow direction to the north-northeast.

Nature and Extent of Contamination. Previous investigations document the presence of industrial solvents in soil and groundwater at the facility. The distribution of contaminants at the site is described in detail in the 1993 RCRA Facility Investigation (RFI) Report and in the results of supplemental investigations and routine groundwater monitoring. A brief summary of the nature and extent of contamination is presented below for soil and groundwater.

Surface Soil. Surface soil samples were collected at 64 locations during the 1986 and 1987 Phase I and II investigations at the Univar site. The primary VOCs detected in surface soil samples during these initial investigations were tetrachloroethene (perchloroethylene or PCE), trichloroethene (TCE), and 1,1,1-trichloroethane (1,1,1-TCA). Results of the soil sampling indicated two main areas of surface soil impacted with VOCs: (1) adjacent to the northwest corner of the drum fill area extending north to the tank farm on the east side of the railroad spur and (2) in the vicinity of the former recycle area, approximately 75 feet west of the corrosives tank farm. The highest PCE, TCE, and 1,1,1-TCA concentrations were 2,900 milligrams per kilogram [mg/kg], 1,300 mg/kg, and 1,600 mg/kg, respectively.

Vadose Zone Soil. Results from laboratory analyses of soil samples collected in the vadose zone 1986 and 1987 Phase I and II investigations and the Phase III investigation conducted from 1988 through 1992 indicate that the highest soil VOC concentrations were located in the chemical handling area. The concentration distributions were similar for PCE, TCE, and 1,1,1-TCA, with the highest concentrations centered near the corrosives tank farm (former drum wash area) and drum fill areas. The highest concentrations of methylene chloride, toluene, ethylbenzene, and total xylenes were located near the drum fill area. Low concentrations of degradation compounds (mainly *trans*-1,2-dichloroethene [*trans*-1,2-DCE], 1,1-dichloroethene (1,1-DCE), and 1,1-dichloroethane [1,1-DCA]) were detected in vadose zone soil at the site.

Shallow Aquifer. The VOC plume in the shallow aquifer is centered in the west-central portion of the site (i.e., source area) and extends in the direction of groundwater flow toward the north and south-southeast. Elevated concentrations of primary or parent chlorinated compounds (PCE, TCE, 1,1,1-TCA) are centered in the source area near monitoring well SMW-7, located adjacent to the northwest corner of the drum fill area, and generally decrease radially and downgradient. The aquitard beneath the shallow aquifer rises sharply to the east of the warehouse, restricting groundwater flow and contaminant transport to the east of the facility. Elevated concentrations of breakdown products (e.g., 1,2-DCE, 1,1-DCA, and vinyl chloride) extend further to the north and south, indicating natural degradation of the parent compounds and production and transport of the degradation products.

Components of the VOC plume extend off site to the west along the entire length of the property. The plume extends off site to the north near SMW-11. At the south end of the site, the VOC plume extends toward SMW-8 and then appears to turn southeast along the property boundary and extends off site at SMW-23. At both the north (SMW-11) and south (SMW-23) ends of the facility, contaminant concentrations appear to decline to very low or nondetectable levels within several hundred feet of the property line. Since startup of the groundwater interim corrective measure (ICM) in March 2002, VOC concentrations near the downgradient edges of the plume have decreased.

Isoconcentration maps for the November 2003 sampling event are included in Appendix A of this report. Historical groundwater data at each monitoring well is presented on constituent versus time plots, also included in Appendix A.

Deep Aquifer. The nature and distribution of contaminants in groundwater in the deep aquifer is the subject of an ongoing supplemental investigation; the results of this initial phase of this investigation were submitted to EPA in a Deep Aquifer Report dated April 14, 2004 (PES, 2004b). As documented in this report, contaminant concentrations were generally much lower in the deeper aquifer with the exception of monitoring well DMW-2 located directly beneath the source area. One of the objectives of the initial phase of the deep aquifer investigation was to determine whether the contaminants at this location are the result of a failed well seal as opposed to migration of contaminants through the aquitard. The Deep Aquifer Report concluded that a leaking or failed well seal was the most likely cause of the elevated levels of VOCs observed in DMW-2 and recommended abandoning this well. DMW-2 was abandoned in January 2005, and deep monitoring wells continue to be monitored as recommended in the Deep Aquifer Report. The report also recommended continuing quarterly water level monitoring and semi-annual water quality sampling.

This CMS does not address potential corrective actions in the deep aquifer. Decisions regarding what, if any, actions are required in the deep aquifer will be deferred until the completion of the ongoing investigation.

Interim Corrective Measures

Univar has implemented a number of interim corrective measures (ICMs), beginning in 1992 with a pilot-scale soil vapor extraction (SVE) system. More recently, an on-site groundwater ICM, consisting of three groundwater extraction wells was installed during late 2001 and early 2002. The groundwater ICM began operations in March 2002. The groundwater ICM provides hydraulic control of the groundwater contamination at the plume perimeter as well as removes contaminant mass. The extracted groundwater is treated by air stripping, and off-gases from the air stripper are treated by resin adsorption. Integrating the ICM into the final corrective measure for the site is an important component of this CMS.

Determination of Cleanup Levels

Cleanup Levels (CULs) were calculated consistent with EPA Region 10 guidance (EPA, 1998a) and the final Revised Technical Memorandum – Cleanup Level Determination Approach (ITC, 2001a). Calculation of CULs involved the following steps:

- Identification of exposure pathways and receptors for developing CULs;
- Selection of chemicals of potential concern (COPCs);
- Calculation of screening levels (SLs);
- Selection of chemicals of concern (COCs); and
- Calculation of CULs and target levels for the COCs (Section 4.1.5).

A detailed description of this process is provided in Appendix E. A brief summary is provided below.

Exposure Pathways and Receptors. Based on the nature and extent of contamination summarized above and the documented uses of the site, surrounding areas, and groundwater, the following potential exposure pathways and receptors have been identified:

Soil

- Inhalation of vapors in a building by on-site office workers; and
- Soil saturation concentrations to prevent non-aqueous phase liquids (NAPL) migration to groundwater due to gravity.

Groundwater

- Inhalation of vapors in a building by on-site office workers;
- Inhalation of vapors in a building by off-site office workers; and
- Inhalation of vapors in a trench by off-site trench workers.

Selection of Chemicals of Concern. A total of 33 COPCs were identified in the Health and Environmental Assessment (HEA) conducted as part of the 1993 RFI (HLA, 1993). These COPCs were retained in both soil and groundwater and no additional screening for COPCs was performed.

To develop the final list of chemicals of concern (COCs) for this CMS, site data for the COPCs were compared to risk-based screening levels based on a 1×10^{-6} excess cancer risk and a hazard index (HI) of 0.1 were calculated for each of the inhalation and soil saturation endpoints identified above. The screening levels for the indoor air quality endpoints (i.e., office workers) were developed using the Johnson and Ettinger model

(JEM) for subsurface vapor intrusion into buildings, as implemented in a spreadsheet system provided by EPA (2003). Screening levels for the off-site trench workers were developed for both subchronic (30-day) and acute (1-hour) trenching scenarios, using an equation that combines an estimate of the steady-state emission flux from the trench floor with a simple box model.

The maximum concentration of each COPC was compared to its corresponding screening level. Maximum concentrations of soil COPCs were obtained from the HEA, combining surface and subsurface soil data. Maximum concentrations of COPCs in the shallow aquifer were obtained from the groundwater monitoring data for 2003.

If the maximum concentration of a COPC did not exceed any of its screening levels in a given medium (soil or groundwater), the chemical was eliminated from further consideration in that medium. Otherwise, the chemical was identified as a COC in that medium.

Twenty COCs were selected for soil: ten based on vapor inhalation, eight based on both vapor inhalation and soil saturation, and two based on soil saturation only. Thirteen COCs were selected for groundwater, all based on vapor inhalation. No COPCs exceeded solubility limits in groundwater.

Calculation of Cleanup Levels. CULs were developed in two steps. In the first step, screening levels were adjusted up by a factor of 10 to create “Base CULs,” which correspond to noncancer HIs of 1.0 and cancer risks of 1×10^{-5} for each individual chemical and each exposure pathway. In the second step, risks were distributed across multiple chemicals and, where applicable, multiple exposure pathways to ensure a total HI of 1.0 and a total cancer risk of 1×10^{-5} . CULs were developed for each of the three receptors identified above: the on-site office worker, the off-site office worker, and the off-site trench worker.

Corrective Action Objectives (CAOs). CAOs form the basis for evaluating potential corrective technologies and actions for the site. CAOs are based on an evaluation of the data from the RFI and on the CULs determined as described above. The focus of the CAOs is protection of human health. No environmental receptors were identified in the HEA or subsequent evaluations.

Soil Corrective Action Objectives. The CAOs for soil at the Univar facility are as follows:

- Prevent inhalation of vapors by indoor workers on site from soil containing COCs that exceed the applicable CULs so that target risk levels are not exceeded (i.e., HI less than 1 and excess cancer risk less than 1×10^{-5});
- Control incidental ingestion of and dermal contact with soil, and inhalation of particulates and vapors from soil, by trench workers on site by using appropriate monitoring and protective equipment;

- Control migration of NAPL from shallow soil containing COCs above the saturation limit; and
- Minimize the potential for contaminants leaching from soil to groundwater.

Groundwater Corrective Action Objectives. The CAOs for groundwater at the Univar facility are as follows:

- Prevent inhalation of vapors by indoor workers on or off site from groundwater containing COCs that exceed the applicable CULs so that target risk levels are not exceeded (i.e., HI less than 1 and excess cancer risk less than 1×10^{-5});
- Prevent inhalation of vapors by trench workers off site from groundwater containing COCs that exceed the applicable CULs so that target risk levels are not exceeded (i.e., HI less than 1 and excess cancer risk less than 1×10^{-5});
- Control inhalation of vapors from groundwater by trench workers on site by using appropriate monitoring and protective equipment;
- Prevent migration of COCs to the Willamette River; and
- Control or reduce the migration of COCs from on-site contamination source areas, to the extent practicable.

Identification and Screening of Corrective Action Technologies

Corrective action technologies are actions that could be implemented to address, whether alone or in combination with other technologies, one or more of the CAOs listed above. A total of 34 potentially applicable technologies were evaluated to address soil treatment, *in situ* groundwater treatment, treatment and disposal of extracted groundwater, air emission treatment, and engineering and institutional controls.

Potentially applicable technologies were screened based on the estimated effectiveness, implementability, and overall applicability to the site. An uncertainty rating was included to reflect additional data or technology development that may be needed to demonstrate applicability to the Univar site. In general, technologies with a low overall applicability were screened out, and technologies with a medium or high applicability were retained. Of the 34 technologies considered, 21 were retained.

Development of Corrective Action Alternatives

Corrective action alternatives (CAAs) are combinations of technologies designed to meet the CAOs. The retained technologies from the technology screening process were assembled into 11 preliminary CAAs that could treat or contain the contaminants in soil and groundwater, protect human health, control the residual contamination source, and reduce contaminant mass. These 11 CAAs were then evaluated (screened) based on

RCRA performance standards to arrive at a final set of alternatives that would be evaluated in detail. The baseline CAA (Alternative 1) was the continued operation of the existing SVE and groundwater ICMs. The remaining 10 CAAs included additional groundwater and/or soil treatment technologies to the ICM to develop a full range of alternatives.

Each of the CAAs include the effects of natural attenuation processes that have been documented at the site. These processes are described in detail in Appendix C, and will effect the overall performance of the CAAs evaluated in this section. Specifically, natural attenuation will effect contaminant distribution and migration and will also contribute to the overall destruction (i.e., mass removal) of contaminants. As such, the natural attenuation processes ongoing at the site will be evaluated as part of the CAAs, and the potential effects of the other corrective measures in a CAA on these natural attenuation processes evaluated.

The evaluation of natural attenuation as part of CAA development and screening should not be confused with, or construed as, implementation of a formal monitored natural attenuation (MNA) corrective action. MNA may be considered in the future as a contingent action after source control and other actions have been implemented. When (and if) an MNA approach is proposed, it will be pursuant to an EPA-approved work plan developed consistent with the EPA OSWER policy document titled "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites" (OSWER Directive 9200.4-17P), or other guidance applicable at the time the work plan is developed.

Based on the CAA screening process, 6 of the 11 CAAs were retained for detailed development and evaluation. The retained CAAs are listed in the table below:

List of Retained CAAs

Alternative	Description
1	Groundwater ICM, Existing SVE, and Natural Attenuation. Serves as Baseline for comparisons
5	Groundwater ICM, Expanded SVE, Source Area Groundwater Extraction, and Natural Attenuation
6	Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area Air Sparging, and Natural Attenuation
7	Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area Steam Sparging, and Natural Attenuation
10	Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area <i>In situ</i> Oxidation, and Natural Attenuation
11	Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area <i>In situ</i> Enhanced Biodegradation, and Natural Attenuation

Evaluation of Corrective Action Alternatives

The retained CAAs listed in the table above were evaluated against the criteria listed in the RCRA Corrective Action Plan (OSWER Directive 9902.3-2A, EPA, 1994). The RCRA Corrective Action Plan establishes a two-tiered approach for evaluation of CAAs, with two corresponding sets of evaluation criteria. In the first tier of the evaluation, the CAAs are evaluated for their ability to meet the following RCRA remedy performance standards (EPA, 1994):

- Protect human health and the environment;
- Attain media cleanup objectives (for current and reasonably anticipated land and resource uses); and
- Remediate the sources of releases to reduce or eliminate further release that might pose threats.

For the Univar site, these three general remedy performance standards are addressed by the CAOs. For those CAAs that, to varying degrees, meet the remedy performance standards, the second stage of the process uses the following balancing criteria:

- Long-term Reliability and Effectiveness;
- Reduction of Toxicity, Mobility, or Volume;
- Short-term Effectiveness;
- Implementability; and
- Cost.

The evaluation was conducted in two stages. Each CAA was first compared individually to each of the criteria listed above. Next, the CAAs were compared against each other for each criteria.

Summary of Detailed Analysis of CAAs. The detailed analysis of alternatives is summarized below for the RCRA performance standards and each of the evaluation criteria.

RCRA Performance Standards. Alternative 7 provides the best performance relative to the RCRA performance standards, primarily due to the aggressive mass removal that could be expected. Alternatives 5, 6, and 11 meet the RCRA performance standards to a slightly lower degree although they still provide a high level of performance. Alternative 10 is slightly lower yet, because, even though the potential for very high levels of mass removal exists in theory, the severe implementability and implementation risk problems lessen the likelihood that the highest level of treatment could be achieved with this technology. Lowest performing of all is Alternative 1, although it does protect human health, does little to treat the source area and stands little chance of attaining media standards over much of the site.

The most important conclusion of the detailed evaluation is that, with the exception of Alternative 1, all of the alternatives perform at a high level against the following two RCRA performance standards:

- **Protect human health** – The alternatives provide a high level of protection to potential on-site and off-site receptors through implementation of the groundwater ICM and the expanded SVE system.
- **Remediate source areas** – All the alternatives significantly reduce mobility and, although the amount of mass removal varies between the alternatives, they all provide significant mass removal in the source area.

By substantially meeting these criteria, all of the alternatives (except Alternative 1) meet all of the CAOs for the site.

Balancing Criteria. Although Alternative 1 is rated as best for the implementability and cost criteria, it ranks by far the worst against the long-term effectiveness and reduction in toxicity, mobility, and volume criteria. As a result, and because it does not substantially achieve the RCRA performance standards, Alternative 1 was not be considered for implementation as the final CAA.

For the remaining alternatives, all perform very well against the long-term effectiveness criteria by providing long-term and reliable protection of human health and the environment. Similarly, the remaining alternatives all perform well against the reduction in toxicity, mobility, and volume criteria. Alternatives 7 and 10 have the potential, at least in theory, to remove more contaminant mass than alternatives 5, 6, and 11 and are therefore rated slightly better.

Unlike the first two criteria, there are significant differences between the alternatives with respect to the remaining three criteria: short-term effectiveness, implementability, and cost. Alternatives 5, 6, and 11 are rated the same and best for short-term effectiveness, while Alternative 7 and especially Alternative 10 are rated much lower due to the significant implementation risks associated with these two alternatives.

Alternatives 5, 6, and 11 are also rated as having similar and moderate implementability, while alternatives 7 and 10 are rated much lower due to the numerous implementation problems. In the case of Alternative 10, these problems are so severe that this alternative is not considered implementable given the assumptions regarding the source area size and contaminant mass present.

Regarding cost, Alternative 5 is rated best for the cost because it provides a high level of risk reduction and source control at the lowest cost of the remaining alternatives. Alternatives 6 and 11 are slightly less cost effective than Alternative 5 due to the increased cost of their approach to source treatment without the added benefit of increased protectiveness. Finally, alternatives 7 and 10 are rated the lowest for cost due to the very high costs.

Recommendation of the Preferred of Corrective Action Alternatives

Based on the evaluation summarized above, Univar has recommended that the preferred CAA for the site be a phased corrective action, with the initial phase being the implementation of Alternative 5. Subsequent phases of the corrective action will include a source area investigation and treatability studies. Based on the results of the source area investigation and treatability studies, and the performance of Alternative 5 over several years of operation, additional corrective actions will be evaluated for potential implementation in the source area.

This preferred corrective action approach:

- Meets the RCRA performance standards and the CAOs;

- Is effective in both the short and long terms;
- Controls the migration of contaminants from the source area;
- Provides significant mass reduction over time;
- Is implementable; and
- Is cost-effective.

This recommended approach to the corrective action is based on certain assumptions, especially those related to the nature and extent of the source area. Additional data collection and evaluation can significantly reduce the uncertainties associated with these assumptions. This data collection should not, however, delay implementation of the first phase of the corrective action (i.e., Alternative 5) as such a delay would defer the protectiveness and other benefits provided by this alternative.

Implementation of Preferred Corrective Action Alternative

The final selection and implementation of the preferred corrective action approach would include the following steps that would generally occur in the order listed:

- Finalize CMS and solicit public and state input on the selection;
- Prepare a statement of basis for the selected alternative and finalize the amendment to 3008(h) administrative order on consent (AOC), including the associated scope of work;
- Prepare the Corrective Measures Implementation (CMI) Work Plan. The CMI Work Plan will describe the documents that will be prepared and the activities that will be performed during the implementation of the preferred alternative. Major components of the CMI Work Plan will include a description of the corrective measure design process, a scope of work for a source area investigation, and a scope of work for treatability studies and data collection requirements;
- Following agency approval and public comment of the corrective action design, initiate construction of the alternative and conduct the source area investigation as described above;
- Begin operations and maintenance of the expanded groundwater extraction and SVE systems; and
- Conduct treatability studies as needed and defined in the treatability study work plan to evaluate what, if any, additional technologies may be applicable or appropriate in the source area based on the refined definition of the source area.

After the above steps have been completed, it is assumed that several years of routine system O&M monitoring would ensue. What, if any, additional actions would occur after these initial years of O&M would be based on several factors including the performance of the source area treatment systems and the results of the natural attenuation monitoring, source area investigation, and treatability study(ies) conducted.

1 INTRODUCTION AND PURPOSE

This report documents the findings of the corrective measures study (CMS) conducted by PES Environmental, Inc. (PES) for the Univar USA Inc. (Univar) facility in Portland, Oregon. Since 1947, Univar has conducted bulk chemical handling and storage at the 9.5 acre facility, located in the heavily industrialized area northwest of downtown Portland (Figure 1-1). Previous investigations document the presence of industrial solvents in soil and groundwater at the facility. The majority of these previous investigations are documented in the Resource Conservation and Recovery Act (RCRA) Facility Investigation Report (RFI Report; Harding Lawson Associates [HLA], 1993).

This CMS was conducted consistent with the Final Corrective Measures Study Work Plan (CMS Work Plan; HLA, 1994) and the Revised CMS Workplan Addendum No. 1 (EMCON, 1997a). These work plans were prepared, as required by the U.S. Environmental Protection Agency Region 10 (EPA), consistent with the provisions of the Administrative Order on Consent (AOC) dated June 15, 1988 (EPA, 1988). The AOC was issued by EPA pursuant to Section 3008(h) of RCRA. The provisions and requirements of the AOC, along with other relevant RCRA regulations and guidance, provided the basis for all environmental activities at the facility including site investigation activities, interim corrective measures (ICMs), and the performance of this CMS.

An on-site groundwater ICM, consisting of three groundwater extraction wells, was installed during late 2001 and early 2002, and began operations in March 2002. The ICM provides hydraulic control of the groundwater contamination at the plume perimeter as well as remove contaminant mass. The extracted groundwater is treated by air stripping, and off-gases from the air stripper are treated by resin adsorption. Integrating the ICM into the final corrective measure for the site is an important component of this CMS.

1.1 Purpose of CMS

As stated in the CMS Work Plan (HLA, 1994), the overall objective of the CMS process is to develop and evaluate corrective action alternatives (CAAs) to address the contaminant releases identified at the site. To achieve this objective, the CMS was conducted consistent with the *RCRA Corrective Action Plan (Final) - OSWER Directive 9902.3-2A* (EPA, 1994) and includes the following elements:

- Identification of specific corrective action objectives (CAOs) for affected media;
- Identification and screening of corrective action technologies;

- Assembly of the retained technologies into a range of CAAs;
- Evaluation of the CAAs against the appropriate performance standards and selection criteria; and
- Selection of a preferred CAA for implementation.

This CMS process is designed to meet RCRA statutory and regulatory requirements, comply with the specific requirements of the AOC, provide a basis for involving the public with the CAA development and selection process, and provide the necessary documentation so EPA can select or approve the most appropriate CAA.

Given the time gap between the approval of the CMS Work Plan and the submittal of the Draft CMS Report in 2001, a brief explanation is warranted. Part of the CMS Work Plan included supplemental treatability testing to support issuance of the National Pollutant Discharge Elimination System (NPDES) permit for proposed ICM actions. Because of issues raised by the City of Portland, the NPDES permit application was rejected and ultimately dropped in late 1994. At approximately this same time, the groundwater flow direction, which previously had been to the west from the central portion of the facility, began to reverse direction due to repair of a leaking stormwater line (see Section 2.4.2). For this and other reasons, the original groundwater ICM plans along the west property boundary were abandoned (see Section 3.3 for details).

Additional groundwater monitoring was performed in 1995 and 1996 to define the effects of the groundwater flow reversal and additional site investigation activities were implemented in 1997 and 1998 to support the evaluation and design of a revised ICM. Concurrent with these supplemental investigations, a revised NPDES permit application was submitted to the Oregon DEQ in 1997. DEQ issued NPDES permit No. 101613 to the facility on September 18, 1998.

Univar initiated CMS related activities in late 1997. The first step in the process was developing the approach that would be used to develop cleanup levels (CULs) for use in the CMS. Univar submitted the draft *Technical Memorandum – Proposed Cleanup Level Determination Approach* (EMCON, 1998a) to EPA for review on January 28, 1998. EPA transmitted their comments on the draft technical memorandum on January 15, 1999. Over the next 6 months, EPA and Univar met several times to try and reach consensus on the CUL development approach, but the parties could not reach agreement on several issues.

On July 15, 1999, Univar submitted a formal request to enter into dispute resolution with EPA on these unresolved issues. Univar withdrew from the dispute resolution process in February 2000 after EPA and Univar came to an agreement. Based on this, Univar and EPA agreed on a cleanup level approach which is described in the April 2001 *Revised Technical Memorandum – Proposed Cleanup Level Determination Approach* (ITC, 2001). The majority of the draft CMS report was subsequently submitted to EPA in September 2001. After resolving several technical issues, the final portions of the draft CMS report were submitted to EPA on January 9, 2002.

EPA provided written comments on the draft CMS report in a September 12, 2002 letter to Univar. This comment letter incorporated comments received from DEQ. One of the major comments related to quantifying the risk associated with air emissions from the groundwater treatment system. Univar proposed an approach to addressing this issue in a November 14, 2002 memorandum; EPA provided comments on this approach in a January 30, 2003 letter (also incorporating DEQ comments). Univar submitted a “redline” version of the CMS report, with the changes to the draft CMS report highlighted, to EPA in May 2003. EPA submitted additional comments focusing on the development of cleanup levels based on indoor air quality in July 2003; the final approach to addressing these issues was finally resolved in a December 17, 2003 meeting at EPA’s offices.

Univar submitted a revised CMS report on February 19, 2004. Following receipt of several additional comments from EPA, Univar submitted a “redline” of the February 2004 CMS report to EPA via e-mail on June 18, 2004. Recently, EPA approved the “redline” version of the CMS as a draft final document in a April 21, 2006 letter (EPA 2006).

This current report represents the June 18, 2004 “redline” document, and no changes were made to the descriptions in the report of contaminant distribution, ICM performance, and the costs associated with the corrective measure alternatives evaluated. Updates on the performance and effectiveness of the ICM and current information on the groundwater plume can be found in the quarterly progress reports submitted to EPA. For clarity, discussions related to the deep aquifer investigation have been updated to reflect post-2003 activities, and the potential implementation dates of the corrective action alternatives have been adjusted to account for the current schedule.

1.2 CMS Report Organization

This CMS report is organized as follows:

- **Section 2** provides a site description (updated since publication of the RFI Report), including an updated discussion of the site hydrogeology, nature and extent of contamination, fate and transport analysis, and an updated site conceptual model.
- **Section 3** describes the ICMs that have been implemented and the related pilot and treatability testing.
- **Section 4** defines the cleanup levels for soil and groundwater, compares contaminant concentrations to these levels, and defines the CAOs and applicable requirements for the site.
- **Section 5** identifies and screens potentially applicable corrective action technologies.

- **Section 6** assembles the retained technologies from Section 5 into a range of preliminary CAAs and screens them against the overall RCRA corrective action performance standards.
- **Section 7** provides detailed descriptions of the retained CAAs, including conceptual design information, estimates of mass removal and contaminant reduction, discussion of estimated cleanup times, and cost estimates.
- **Section 8** documents the detailed analysis of the CAAs using RCRA corrective action balancing criteria.
- **Section 9** recommends a preferred CAA for implementation, and discusses the major issues related to implementing the preferred CAA.
- **Section 10** provides a preliminary discussion of the public involvement approach for implementing the final CAA.

1.3 Historical Facility Name Changes and Consultant Changes

As noted above, this facility has been in continuous operation at this location since 1947. From 1947 until April 2, 2001, the facility operated under the name of Van Waters & Rogers Inc. (VW&R). From April 2001 until June 2002, the facility name changed to Vopak USA Inc. (Vopak) due to a change in corporate ownership. In June 2002, corporate ownership changed again and the facility name changed to Univar USA Inc. Key Univar personnel familiar with facility operations in general and the environmental activities described in this document have, in general, remained the same throughout the last 15 years.

When environmental investigations began at the facility in the mid-1980s, Harding Lawson Associates (HLA) was retained by VW&R to assist them with the project. HLA remained as the lead environmental consultant for the project until approximately 1995. During this time, HLA performed the majority of the site investigation activities and prepared the RCRA Facility Investigation (RFI) Report in 1993. In 1995, VW&R changed consultants from HLA to EMCON Inc. (EMCON). EMCON conducted additional investigation activities, initiated work on the ICM design and implementation, and conducted the majority of the CMS work. In August 2000, IT Corporation (ITC) acquired EMCON Inc. and continued to provide consulting services until December 2001 at which time Univar retained PES to provide project related consulting services. Since EMCON began work on the project in 1995, key project personnel have remained with the project throughout the ITC and PES changes.

2 SITE DESCRIPTION AND CURRENT CONDITIONS

This section describes historical operations at the Univar site and discusses land use, previous investigations, the hydrogeologic setting, and the nature and distribution of chemicals in soil and groundwater.

2.1 Site Description and History

The Univar facility is located at 3950 NW Yeon Avenue in a heavily industrialized area northwest of downtown Portland, Oregon. The site is located approximately 0.5 miles south of the Willamette River and 0.25 miles north of the Tualatin Mountains. It is bounded to the west by NW St. Helens Road and to the south by NW Nicolai Street.

The facility encompasses approximately 9.5 acres, including approximately 2 acres of warehouses and office space, a railroad spur, loading dock, and aboveground storage tanks (Figure 2-1). The railroad spur runs along the west side of the warehouse and loading dock. More than 90 percent of the site is capped with buildings, the concrete loading dock area and asphalted apron, and parking areas. A small landscaped area is located in front of the office and around the front parking area. The site is surrounded by a chain link fence with access via two security gates at either side of the front of the facility.

Univar has packaged, stored, and distributed bulk chemicals at the facility since 1947. Bulk chemicals were stored in 13 underground storage tanks, all of which were removed in 1985. At the time of removal, the tanks were tested and found to be tight. No soil sampling was conducted as part of the removal.

The recycling of spent chlorinated solvents began in 1973, together with the storage of certain hazardous wastes associated with the recycling facility. The recycling and storage of associated hazardous waste were suspended in 1987. The hazardous wastes storage facility underwent procedural closure under Section 3008(a) of RCRA in 1988.

Four chemical releases at the facility were reported between 1979 and 1985. These included a trichloroethene (TCE) release immediately south of the former recycling area, a release of a blend of methylene chloride (MC) and toluene adjacent to the loading dock near the drum fill area, an MC release adjacent to the loading dock south of the drum fill area, and a mineral acid release on the east side of the facility northeast of the fill shed. Additional chemicals present in soil and groundwater have been characterized and will be included as part of the CMS.

2.2 Land Use

The Univar facility is located on the south side of Yeon Avenue in the Northwest Industrial neighborhood of Portland. The site is zoned heavy industrial and lies within an area designated as an Industrial Sanctuary in the City of Portland Comprehensive Plan. Facilities near the Univar site include American Steel, the McWhorter facility (also known as McCloskey Varnish), and the Equilon (formerly Texaco) petroleum tank farm to the west; the former Convoy and ANR facilities to the east and southeast; and the Index and Wilhelm Trucking facilities to the south. The area has been industrialized for approximately 60 years, and the nearest residential neighborhood is located approximately 2,000 feet south of the site, in the Tualatin Mountains.

2.3 Previous Investigations

Three phases of field investigation activities were performed between 1987 and 1992 in an attempt to characterize the subsurface conditions at the site. The Phase I and II field investigations are summarized in Section 2.3 of the RFI report (HLA, 1993). The Phase III investigation is detailed in Section 4.0 of the RFI report (HLA, 1993). These investigations included collecting and analyzing surface soil samples at 64 locations; collecting and analyzing soil samples from 54 borings; performing two soil gas surveys; performing cone penetration tests; installing, sampling, and analyzing groundwater and soil gas samples from 23 groundwater and 4 soil gas monitoring wells; and performing aquifer tests. Quarterly and semiannual groundwater monitoring programs were implemented and are currently ongoing at the site to monitor groundwater flow and contaminant distribution and migration.

Since the RFI, supplementary site characterizations (ITC, 1997a) and interim corrective measures design were conducted at the north and south ends of the site, deep aquifer evaluations were performed at and to the east of deep well DMW-2 (Figure 2-2), and a regional groundwater survey was coordinated. South end supplementary site investigations included drilling and sampling of soil probes GP-1 through GP-9 and GP-13 through GP-16, and monitoring wells SMW-23 and SMW-24 in 1997. North end supplementary site investigations included drilling and sampling of soil probes GP-10 through GP-12 and SMW-25 through SMW-27 in 1997 and 1998. Extraction well EXW-2 and piezometers PZ-1 through PZ-5 were installed and aquifer tests were performed at the south end of the site as part of interim corrective measures design in 1997 and 1998 (ITC, 2000). Similarly, extraction wells EXW-3 and EXW-4 and piezometers PZ-6 through PZ-9 were installed and aquifer tests were performed at the north end of the site in 2000 (ITC, 2000).

Deep aquifer evaluations included the installation of deep monitoring wells DMW-4 and DMW-5 to the east and southeast of DMW-2, respectively. Additionally, a second deep well (DMW-2a) was installed in November 2000 near DMW-2 to determine if the increasing volatile organic compound (VOC) concentrations in groundwater at deep aquifer monitoring well DMW-2 were caused by a preferential contaminant pathway created by the DMW-2 well construction. Based on a comparison of the DMW-2 and

DMW-2a results, a determination could not be made as to whether or not the DMW-2 well construction caused a preferential migration pathway. It was concluded that a more extensive deep aquifer investigation was needed (ITC, 2001b).

A work plan for installing additional deep wells to the northwest and northeast of DMW-2 (ITC, 2001d) was approved by EPA in October 2001. Deep monitoring wells DMW-6 and DMW-7 were installed in September and June 2002 with the screen intervals located within the coarse gravel and sand aquifer, below the transitional silty sand interbeds. Groundwater levels were monitored on a monthly basis and groundwater samples were collected quarterly in 2002 and 2003.

Results of the initial phase of the deep aquifer investigation (e.g., additional well installation and sampling) were evaluated in early 2004 and presented to EPA in the April 14, 2004 Deep Aquifer Investigation report (PES, 2004b); the results are discussed in Sections 2.4 and 2.5. The 2004 report recommended abandoning DMW-2, and after obtaining EPA's concurrence, DMW-2 was abandoned in January 2005.

2.4 Geologic and Hydrogeologic Setting

2.4.1 Regional Hydrogeology

Geology. The Univar facility is located on the Willamette River floodplain approximately 2,200 feet south of the river and 1,000 feet north and northeast of the Tualatin Mountains. The floodplain is relatively flat, with the ground surface at the facility approximately 35 feet above mean sea level, or about 20 to 25 feet above the typical river level.

The floodplain near the facility is underlain by artificial fill, Quaternary alluvial and lacustrine deposits, the Pliocene Troutdale Formation, and Tertiary Columbia River Basalts (from youngest to oldest). Much of the artificial fill in the vicinity of the Univar facility consists of sand and silt dredged from the Willamette River that was used to fill in shallow Guilds Lake between 1910 and 1930. Most of the Univar facility lies over the footprint of the lake. Artificial fill on the floodplain is also composed of coarser and more variable grade fill at the surface. The river and lake deposits are composed of interbedded and laterally discontinuous layers of fine sand, silt, and silty clay that are reported to be at least 50 feet thick near the facility (HLA, 1993). The Troutdale Formation, which consists of sandstone and conglomerate, lies beneath the unconsolidated river and lake deposits and is exposed at the base of the Tualatin Mountains south of the Univar facility. The Columbia River Basalts are thick regional lava flows which lie beneath the Troutdale Formation and compose the Tualatin Mountains.

Groundwater. The shallowest aquifer in the area consists of Quaternary alluvial and lacustrine deposits. Based on site characterization investigations performed at industrial facilities in the area, depth to groundwater ranges from less than 10 feet to 20 feet below

ground surface (bgs) with variable groundwater flow directions. The most productive aquifers in the region consist of the Troutdale Formation and the Columbia River Basalts. Near the Univar facility, depth to water in wells screened in these units is reported to be approximately 30 feet bgs.

2.4.2 Site Hydrogeology

Geology. Grade fill is the uppermost geologic unit found beneath the site (Figures 2-3, 2-4, and 2-5). The grade fill is up to approximately 5 feet thick and consists primarily of gravel with fine to medium sand and silt.

Beneath the grade fill lies the layer of dredged sand, silt, and clay that was used to fill in Guilds Lake. The upper part of the dredge fill layer, which was encountered in most borings at the site, consists of sandy silt, silt, clay, and interbedded silt and sand. This finer dredge fill layer ranges from approximately 1 to 27 feet thick. The lower part of the dredge fill layer consists of dark gray, fine to medium sand with local interbeds of silty sand, silt, and clay. The coarser dredge fill layer is up to approximately 29 feet thick; it pinches out to the east and southwest.

Native alluvial and lacustrine soil lies beneath the dredge fill layer. The native alluvial and lacustrine soil is similar in composition to the upper part of the dredge fill layer. It consists of dark gray silt, sandy silt, elastic silt, clay, clay with sand, and silty sand. The unit was found between 14 and 75 feet bgs, ranging in thickness from about 28 to at least 45 feet. In the deeper borings drilled at the site, the base of this unit was encountered at depths ranging from 57 to 80 feet bgs.

Alluvial gravel and sand is found below the native alluvial and lacustrine soil. Prior to installation of deep monitoring well DMW-2a, the deepest borings at the site just contacted the top of this unit. At DMW-2a, this unit was found to consist of coarse gravel with cobbles and fine to medium sand (ITC, 2001b), and at DMW-6 and DMW-7 this unit was found to consist of fine to coarse, rounded gravel with cobbles and fine to coarse sand. This unit was 5 feet thick at DMW-6 and 14 feet thick at DMW-7 and was encountered between 57 feet and 94 feet bgs; based on the existing deep borings, the unit dips to the north and east.

Clay, silt, and sandy silt were found below the sand and gravel at DMW-6. The silt contains some fine gravel. Although 37 feet of this unit was penetrated at DMW-6, the base of the unit was not encountered to a depth of 100 feet. Weathered bedrock consisting of siltstone and sandstone was encountered at DMW-7. Three feet of this unit was penetrated at DMW-7 between 94 and 97 feet bgs.

Hydrostratigraphic Units. Two aquifers and two aquitards have been identified beneath the site. The sandy lower part of the dredge fill composes the shallow aquifer. This aquifer is present throughout the site. However, the thickest portions of the shallow aquifer are along the west side of the warehouse and railroad spur, to the north of the main office, and along the southern property boundary. The top of the underlying

aquitard rises sharply to the east of the warehouse and to the southwest of the site, limiting the thickness of the shallow aquifer in these areas (Figure 2-6). Native silt and clay compose the intermediate aquitard. The aquitard is of low permeability and serves as a barrier to downward groundwater flow. To the east of the warehouse and to the southwest of the site where the aquitard rises sharply, it also serves as a barrier to horizontal groundwater flow, directing groundwater flow to the north and south.

Gravel and sand, likely alluvial in origin, compose the deep aquifer. The transitional silty sand interbeds at the base of the aquitard, monitored by DMW-1, DMW-2, DMW-3, DMW-4, and DMW-5, are likely hydraulically connected to the deep aquifer. Clay, silt, sandy silt, and bedrock compose the basal aquitard. Like the intermediate aquitard, the basal aquitard is of low permeability and serves as a barrier to downward groundwater flow.

Groundwater Elevations. Approximate depth to groundwater in the shallow aquifer ranges from 6 to 13.8 feet bgs. Shallow aquifer groundwater elevations range from approximately 23.8 to 28.5 feet above the City of Portland datum. The lowest shallow aquifer groundwater elevations at the site are to the north of the office and southeast of the southern property boundary. The highest shallow aquifer groundwater elevations are west of the warehouse and railroad spur. In monitoring wells completed in the deep aquifer and transitional silty sand interbeds at the base of the aquitard, approximate depth to groundwater ranges from 7 to 17.5 feet bgs.

Deeper groundwater elevations range from 19.7 to 27.5 feet above the City of Portland datum, with the highest elevations generally to the east of the loading dock and the lowest elevations to the west of the warehouse. Groundwater elevations in deeper wells were lower than groundwater elevations in adjacent shallow wells. Groundwater elevations generally are highest in spring and lowest in fall. Figures 2-7 and 2-8 present typical shallow aquifer groundwater elevation contours under non-pumping and pumping conditions, respectively. Figure 2-9 presents typical deep monitoring well groundwater elevations.

Groundwater Flow. Groundwater in the shallow aquifer flows toward the site from the west and splits into southerly and northerly flow beneath the site. This bifurcated flow is caused by the high elevation of the top of the relatively low permeability aquitard to the east of the loading dock and to the southwest of the site. The low permeability aquitard directs flow along a relatively thick channel in a shallow aquifer that lies beneath the western loading dock. Prior to 1995, shallow groundwater flowed to the north, west, and south from a groundwater mound beneath the facility. Univar removed several water sources from the groundwater mound area by replacing a leaking 10-inch diameter stormwater line on the south side of the warehouse in late 1993 and a leaking steam line west of the rail spur near the former recycling area in 1996. Since ICM startup, extraction wells located at the south, northwest, and north parts of the site have created well-defined cones of depression around each of the extraction wells (Figure 2-8). Groundwater along the northern and southern property lines is being captured by ICM groundwater extraction at EXW-4a and EXW-2, respectively.

Approximate horizontal groundwater gradients in the shallow aquifer are less than 0.002 feet per foot (ft/ft) on the west side of the rail spur and at the central part of the facility, 0.006 ft/ft at the north part of the site, and 0.006 ft/ft at the south part of the site. The vertical groundwater gradient across the aquitard is downward at approximately 0.1 ft/ft. The results of the RFI slug tests indicate a shallow aquifer hydraulic conductivity range of 0.27 to 244 feet per day (HLA, 1993). The horizontal hydraulic conductivities of the shallow aquifer, estimated from the RFI constant-rate and recovery tests, range from 240 to 680 ft/day. The horizontal hydraulic conductivity of the shallow aquifer has been measured in aquifer tests at SMW-5, EXW-2, EXW-3, and EXW-4; the hydraulic conductivity in these tests was estimated to be 300, 210, 200, and 150 feet/day, respectively (ITC, 2000a). The vertical hydraulic conductivity of the aquitard was measured in the laboratory; it was 1.5×10^{-6} cm/sec in both samples measured (ITC, 2001b).

Groundwater velocity can be calculated using the following form of Darcy's Law:

$$v = (K \times i)/n_e$$

where

v = average linear groundwater velocity (ft/day),

K = saturated hydraulic conductivity (ft/day),

i = hydraulic gradient (ft/ft), and

n_e = effective porosity (unitless).

Using a porosity of 0.40 typical of unconsolidated sand and silt (Wolff, 1982) and the parameters listed above, the average linear groundwater velocity in the shallow aquifer is estimated to be less than 550 feet per year (ft/yr) to the west of the rail spur and in the central part of the site. The average linear groundwater velocity in the shallow aquifer is estimated to be 1,100 ft/yr at the north part of the site and 1,150 ft/yr in the south part of the site. Because of attenuation of contaminants in groundwater, contaminant transport velocities are considerably slower than the estimated groundwater flow velocities (see Section 2.6). The vertical groundwater velocity across the aquitard is estimated to be 0.42 ft/yr.

Based on monthly groundwater elevation measurements in DMW-2a, DMW-6, and DMW-7 during 2002 and 2003, the horizontal hydraulic gradient in the deep aquifer is extremely flat (typically at or below 0.001 feet/foot). This results in apparent variable flow directions. Although the most common flow direction determined from the monthly data is to the north-northeast, flow has also been measured in the south and southeast directions. The deep aquifer wells have been on occasion under pressure, and when pressure has been noted in the wells, they have been allowed to equilibrate with the caps off for a period of time (generally more than an hour) prior to water level measurement. Despite these attempts to allow the water levels to stabilize, deep aquifer groundwater flow directions continue to be variable.

2.4.3 Beneficial Uses of Groundwater

A groundwater beneficial use evaluation was performed in April 1999 (EMCON, 1999a). This evaluation was conducted consistent with Oregon Administrative Rules Chapter 340, Division 122 (OAR 340-122). Under OAR 340-122-155(9), beneficial uses of water are “any current or reasonably likely future beneficial uses of groundwater or surface water by humans or ecological receptors.”

Scope of Beneficial Use Study. The beneficial use study evaluated the following factors:

- Federal, state, and local regulations governing the appropriation and/or use of water;
- Nature and extent of current groundwater and surface water uses;
- Suitability of groundwater and surface water for beneficial uses;
- Contribution of water to the maintenance of aquatic or terrestrial habitat;
- Beneficial use of water that the Water Resources Department or other federal, state, or local programs are managing in the location of the facility; and
- Reasonably likely future uses of groundwater and surface water based on:
 - Historical land and water uses;
 - Anticipated future land and water uses;
 - Concerns of community and nearby property owners regarding future water use;
 - Regional and local development patterns;
 - Regional and local population projections; and
 - Availability of alternate water sources including, but not limited to, public water supplies, groundwater sources, and surface water sources.

The shallow and deep zones of the alluvial aquifer at the site and within 1,000 feet downgradient of the site were considered areas that may be reasonably likely to come in contact with facility-related hazardous substances.

Beneficial Use Study Findings. The Water Rights Division of the Oregon Water Resources Department indicated that no groundwater rights existed near the Univar facility and that the only surface water right (located 2,000 feet north of the facility on the Willamette River) was unused and soon to be canceled. The Oregon Health Department indicated that water was supplied to the Northwest Industrial neighborhood by the City of

Portland Water Bureau. Agency personnel did not indicate management of any beneficial use of water in the locality of the facility by federal or Water Resource Department programs. A review of well logs at the Water Resources Department found only three water supply wells in the Willamette River Valley within a 1-mile radius of the site. All three wells were industrial (non-potable) supply wells completed within the basalt bedrock and all were at least 1,800 feet from the facility. Based on the locations and depths of completion, the three wells are not considered to be reasonably likely to come in contact with facility-related hazardous substances.

The suitability of groundwater for beneficial uses in the alluvial deposits in the vicinity of the Univar facility appears to be suspect due to natural iron concentrations above the secondary maximum contaminant level and the variable thickness and yield of the shallow aquifer. Although groundwater in the Northwest Industrial neighborhood flows to the Willamette River, resulting from the very high river flow rate relative to groundwater flow rate, the contribution of groundwater to the maintenance of aquatic or terrestrial habitat is considered very low.

The area around the Univar facility is zoned for heavy industrial use and will likely remain such in the future. Based on the Regional Water Supply Plan developed by the Portland Water Bureau and 26 other municipal water suppliers (Water Providers of the Portland Metropolitan Area, 1996), it is extremely unlikely that groundwater in the Northwest Industrial neighborhood would be developed as a municipal supply. If needed, the closest planned future sources of groundwater are more than 6 miles from the facility. Groundwater in the Northwest Industrial neighborhood could, however, be developed in the future for industrial purposes, but if it were, the wells would likely be installed in the deeper basalt bedrock aquifer. During development of the Regional Water Supply Plan, extensive public and stakeholder input was solicited; no concerns were raised about the potential future use of groundwater in the Northwest Industrial neighborhood.

Beneficial Use Study Conclusions. Based on the long-term heavy industrial use of the area around the Univar facility, the lack of historical and current groundwater use near the facility, the generally low background quality of shallow groundwater in the area, the abundant supply of high quality water from the Portland Water Bureau, and the lack of future planned groundwater use in the area, there are no current or reasonably likely beneficial uses of groundwater in the locality of the Univar facility. In a June 3, 2004 meeting, and for purposes of this CMS, EPA and DEQ have concurred with this conclusion. Therefore, direct use of the groundwater in the locality of the Univar facility (e.g., drinking water, industrial use) are not complete exposure pathways and will not be evaluated.

2.4.4 Summary

The Univar facility is located on the Willamette River floodplain approximately 2,200 feet south of the river and 1,000 feet north and northeast of the Tualatin Mountains. The floodplain near the facility is underlain by artificial fill, Quaternary alluvial and

lacustrine deposits, the Pliocene Troutdale Formation, and Tertiary Columbia River Basalts (from youngest to oldest). The shallowest aquifer in the area consists of Quaternary alluvial and lacustrine deposits. Based on site characterization investigations performed at industrial facilities in the area, depth to groundwater ranges from less than 10 feet to 20 feet below ground surface (bgs) with variable groundwater flow directions.

Six geologic units have been identified beneath the facility (Figures 2-3, 2-4, and 2-5):

1. Grade fill, found from the surface to a depth of 5 feet;
2. Dredged sand, silt, and clay, found between 1 and 32 feet bgs, ranging in thickness from about 13 to 31 feet; the lower sandy portion constitutes the shallow aquifer and is found between 2 and 32 feet bgs, ranging up to 29 feet thick (pinching out to the east and southwest);
3. Alluvial and lacustrine silt and clay (intermediate aquitard), found between 14 and 75 feet bgs, ranging in thickness from approximately 28 to at least 45 feet;
4. Alluvial gravel and sand (lower aquifer), found between 57 and 94 feet bgs, ranging in thickness from about 5 to 14 feet;
5. Clay, silt, and sandy silt; found between 63 feet and 100 feet bgs in DMW-6; and
6. Weathered bedrock consisting of siltstone and sandstone, encountered below depths of at least 94 feet bgs.

Approximate depth to groundwater in the shallow aquifer ranges from 6 to 13.8 feet bgs. Shallow aquifer groundwater elevations range from approximately 22.8 to 28.5 feet above the City of Portland datum. In monitoring wells completed in the deep aquifer and transitional silty sand interbeds at the base of the aquitard, approximate depth to groundwater ranges from 7 to 17 feet bgs. Deeper groundwater elevations range from 19.7 to 27.5 feet above the City of Portland datum. Groundwater in the shallow aquifer flows toward the site from the west and splits into southerly and northerly flow beneath the site. The average linear groundwater velocity in the shallow aquifer is estimated to range from less than 550 ft/yr to 1,150 ft/yr. The vertical groundwater velocity across the aquitard is estimated to be 0.42 ft/yr. Groundwater flow in the deep gravel aquifer is variable with the most common flow direction to the north-northeast.

2.5 Nature and Distribution of Contaminants

2.5.1 Soil

The following sections summarize the analytical results of soil samples collected at the site. Surface soil and vadose zone soil results are from the RFI report (HLA, 1993). Saturated soil results are from the RFI report and the DMW-2a installation report (ITC, 2001b). Sampling locations are shown on Figure 2-10.

Surface Soil. Surface soil samples were collected at 64 locations during the 1986 and 1987 Phase I and II investigations at the Univar site. A detailed discussion of the surface soil results are presented in the Phase I and II investigation reports (HLA, 1987a and 1987b). Soil samples were typically collected between 10 and 16 inches bgs. The only VOCs detected in surface soil samples during these initial investigations were tetrachloroethene (perchloroethylene or PCE), TCE, and 1,1,1-trichloroethane (1,1,1-TCA), with the exception of two soil samples containing MC in the vicinity of the drum fill area. Results of the soil sampling indicated two main areas of surface soil impacted with VOCs. The highest PCE, TCE, and 1,1,1-TCA concentrations (2,900 milligrams per kilogram [mg/kg], 1,300 mg/kg, and 1,600 mg/kg, respectively) were found adjacent to the northwest corner of the drum fill area (surface soil sampling location M-113). Elevated VOC concentrations in surface soil in this area extended north to the tank farm and were confined to the east side of the railroad spur.

The other main area of contamination was in the vicinity of the former recycle area, approximately 75 feet west of the corrosives tank farm. The highest VOC concentrations in this area (soil boring DB-1) were 1,600 mg/kg PCE, 880 mg/kg TCE, and 650 mg/kg 1,1,1-TCA. Low concentrations (less than 10 mg/kg) of PCE, TCE, and 1,1,1-TCA were present in surface soil samples throughout the chemical handling area, which includes the tank farm, the drum fill area, the former recycle area, and the solvent tank farm.

Vadose Zone Soil. Results from laboratory analyses of soil samples collected in the vadose zone 1986 and 1987 Phase I and II investigations and the Phase III investigation conducted from 1988 through 1992 indicate that the highest soil VOC concentrations were located in the chemical handling area. The concentration distributions were similar for PCE, TCE, and 1,1,1-TCA, with the highest concentrations centered near the corrosives tank farm (former drum wash area) and drum fill areas. The highest concentrations of MC, toluene, ethylbenzene, and total xylenes were located near the drum fill area. No benzene concentrations greater than 1 mg/kg were detected in soil samples collected at the site. Low concentrations of degradation compounds (mainly *trans*-1,2-dichloroethene [*trans*-1,2-DCE], 1,1-DCE, and 1,1-dichloroethane [1,1-DCA]) were detected in vadose zone soil at the site. Based in the soil data summarized in the RFI report, the following is a brief description of the concentrations and distribution of the primary VOCs present in soil at the site.

- **Tetrachloroethene.** The highest concentration of PCE (14,000 mg/kg) was found in a DB-6 soil sample collected at 9 feet bgs to the west of the corrosives tank farm. Numerous borings located in the chemical handling area had soil samples with significant PCE concentrations (greater than 100 mg/kg) in unsaturated soil at or above the water table. The vertical concentration distribution of PCE in the majority of the soil borings within the vadose zone soil showed that the highest concentrations were located in shallow soil (less than 3 feet bgs) and decreased with depth. Soil sample results indicate that PCE-impacted soil above 10 mg/kg extends approximately 400 feet in the north/south direction within the chemical handling area.

- **Trichloroethene.** The highest concentration of TCE (1,700 mg/kg) was found in a soil sample collected at 3 feet bgs near the northwest corner of the drum fill area (SMW-7). Three soil borings located within the chemical handling area had TCE concentrations in soil above 100 mg/kg. TCE concentrations in vadose zone soil decreased with depth, with the exception of one soil boring (DB-6) located south of the former solvent recycling area where the TCE concentration increased significantly with depth. Soil sample results with TCE concentrations greater than 10 mg/kg were similar to the 10 mg/kg PCE distribution, with the exception of DB-22 located on the south side of the warehouse (TCE concentration of 35 mg/kg).
- **1,1,1-Trichloroethane.** The highest concentration of 1,1,1-TCA (2,300 mg/kg) was found in a soil sample collected at 5.3 feet bgs near the northwest corner of the drum fill area (SMW-7). The results of soil samples with concentration of 1,1,1-TCA greater than 100 mg/kg are similar to the results of the TCE analysis at the site. The extent of 1,1,1-TCA greater than 10 mg/kg is limited to the area west of the corrosives tank farm and the drum fill area.
- **Methylene Chloride.** The highest concentration of MC (1,200 mg/kg) was found in a DB-11 soil sample collected at 2.7 feet bgs near the southwest corner of the drum fill area. MC was detected above 10 mg/kg in four soil borings (DB-3, DB-4, DB-11, and SMW-7), all located within or near the historical MC spill area on the west side of the drum fill area.
- **Aromatic Hydrocarbons.** The highest concentrations of toluene, ethylbenzene, and total xylenes in soil (4,300 mg/kg, 610 mg/kg, and 3,050 mg/kg, respectively) were collected from a soil boring located northwest of the drum fill area (SMW-7). Additionally, soil samples collected from DB-7, DB-11, DB-12, and DB-20 had toluene concentrations greater than 10 mg/kg. The remaining vadose zone soil samples collected from the borings had toluene concentrations of less than 10 mg/kg. Ethylbenzene and total xylenes concentrations above 10 mg/kg were detected at DB-7, DB-11, DB-15, and DB-20. Some low concentrations (less than 10 mg/kg) of these compounds were detected in soil borings at DB-12 and DB-16.

Saturated Soil. Soil samples were collected below the water table during the installation of monitoring wells DMW-2 in 1988 and DMW-2a in 2000. DMW-2 samples were collected at depths of 35, 47, and 49.8 feet bgs (aquitard) and 57 feet bgs (top of the deep aquifer). DMW-2a samples were collected at depths of 21.5 and 24.5 feet bgs (near the base of the shallow aquifer); 29, 37, 39, 46.5, 49, and 51.5 feet bgs (aquitard); and 56.5 and 58.5 feet bgs (top of the deep aquifer). Detectable concentrations of VOCs were found in soil samples collected near the base of the shallow aquifer, with concentrations from one to three orders of magnitude lower than those found in surface and vadose zone soil. VOC concentrations significantly declined in the upper half of the aquitard.

Detected VOC concentrations at the base of the shallow aquifer ranged from 0.0087 to 0.7 mg/kg. PCE, TCE, 1,1,1-TCA, MC, acetone, and 4-methyl-2-pentanone were detected at concentrations up to 0.26, 0.047, 0.023, 0.028, 0.13, and 0.7 mg/kg, respectively. Toluene, ethylbenzene, and total xylenes were detected at concentrations up to 0.48, 0.18, and 0.56 mg/kg, respectively.

VOCs were detected in aquitard soil samples to a depth of 49.8 feet bgs, with the exception of a low-level DMW-2a toluene detection in a sample collected at a depth of 51.5 feet bgs. At least one VOC was detected in all DMW-2 aquitard soil samples. In soil samples collected from DMW-2a, PCE, TCE, *cis*-1,2-dichloroethene (1,2-DCE), MC, acetone, and 4-methyl-2-pentanone were detected at concentrations up to 0.033, 0.015, 0.52, 0.030, 0.55, and 0.92 mg/kg, respectively; toluene, ethylbenzene, and total xylenes were detected at concentrations up to 0.58, 0.061, and 0.178 mg/kg, respectively. In soil samples collected from DMW-2, PCE, TCE, *trans*-1,2-DCE, vinyl chloride (VC), and MC were detected at concentrations up to 0.22, 0.56, 0.040, 0.14, and 0.52 mg/kg, respectively; toluene and total xylenes were detected at concentrations up to 0.99 and 0.36 mg/kg, respectively.

VOCs were not detected in either DMW-2a deep aquifer soil sample. Only MC (0.13 mg/kg) was detected in the DMW-2 deep aquifer soil sample collected at a depth of 57 feet bgs.

2.5.2 Groundwater

The following sections detail the analytical results from groundwater sampling performed at the site in both the shallow and deeper water bearing zones. Figure 2-2 shows the locations of the monitoring wells at the site.

The discussion below is representative of conditions through November 2003. The ICM groundwater extraction system began operation in March 2002.

Shallow Aquifer. The nature and distribution of contaminants in groundwater in the shallow aquifer is described in this section. For the purpose of the CMS, the results from groundwater samples collected in November 2003 will be detailed in the following sections. Isoconcentration maps for the November 2003 sampling event are included in Appendix A. In general, these isoconcentration maps reflect existing conditions since the start of the ICM; isoconcentration maps for previous sampling events are available in progress reports previously submitted to EPA. In order to see how the distribution of contaminants has changed since the groundwater flow direction changed in 1995, the groundwater elevation contour map and isoconcentration plots for select chemicals presented in the RFI report (HLA 1993) are include in Appendix A. Historical groundwater data at each monitoring well is presented on constituent versus time plots, also included in Appendix A.

The VOC plume is centered in the west-central portion of the site (i.e., source area; see Section 2.5.3) and extends in the direction of groundwater flow toward the north and

south-southeast. Elevated concentrations of primary or parent chlorinated compounds (PCE, TCE, 1,1,1-TCA) are centered in the source area near SMW-7, located adjacent to the northwest corner of the drum fill area, and generally decrease radially and downgradient. As discussed in Section 2.4.2, the aquitard beneath the shallow aquifer rises sharply to the east of the warehouse, restricting groundwater flow and contaminant transport to the east of the facility. Elevated concentrations of breakdown products (e.g., 1,2-DCE, 1,1-DCA, VC) extend further to the north and south, indicating natural degradation of the parent compounds and production and transport of the degradation products (see Section 2.6 and Appendix C for discussion of natural degradation processes occurring at the site).

Components of the VOC plume extend off site to the west along the entire length of the property. The plume extends off site to the north near SMW-11. At the south end of the site, the VOC plume extends toward SMW-8 and then appears to turn southeast along the property boundary and extends off site at SMW-23. At both the north (SMW-11) and south (SMW-23) ends of the facility, contaminant concentrations appear to decline to very low or nondetectable levels within several hundred feet of the property line. Since ICM startup in March 2002, VOC concentrations near the downgradient edges of the plume have decreased.

The following is a brief description of the concentrations and distribution of the main VOC contaminants present in the shallow aquifer at the site based on the November 2003 groundwater monitoring data.

- **Tetrachloroethene.** The highest PCE concentration in groundwater was found at monitoring well SMW-7 (55,000 micrograms per liter [$\mu\text{g/L}$]). Monitoring well SMW-4, located approximately 100 feet to the northwest of SMW-7, had a groundwater PCE concentration of 6,400 $\mu\text{g/L}$. PCE concentrations in groundwater decrease significantly away from these two source area well locations. Concentrations of PCE in groundwater of 110, 1,200, and 1,100 $\mu\text{g/L}$ were found in monitoring wells SMW-1, SMW-5, and SMW-6, respectively, in the downgradient direction to the north. Piezometer PZ-7, located northwest of the warehouse building, had the northernmost detectable concentration of PCE. Monitoring well SMW-15, located west of the former solvent recycling area, had the westernmost detection of PCE. Low-level concentrations of PCE have been detected intermittently in monitoring wells west and south of the source area in past events.
- **Trichloroethene.** The highest TCE concentration in groundwater was found at monitoring well SMW-7 (44,000 $\mu\text{g/L}$). Elevated concentrations of TCE in groundwater were detected to the north of SMW-7 in monitoring wells SMW-1 (210 $\mu\text{g/L}$), SMW-4 (3,900 $\mu\text{g/L}$), SMW-5 (4,900), SMW-6 (3,800 $\mu\text{g/L}$), SMW-26 (340 $\mu\text{g/L}$), and PZ-7 (880 $\mu\text{g/L}$), and at a much lower concentration south of SMW-7 in monitoring well SMW-8 (25 $\mu\text{g/L}$). The northernmost detectable concentration of TCE was present in groundwater in extraction well EXW-4a. There have been sporadic low-level detections at the north end of the site in previous events. Monitoring wells located to the west on the American

Steel property (SMW-13 and SMW-15) had concentrations of TCE in groundwater of 0.6 and 35 µg/L, respectively. Piezometers PZ-3 and PZ-5 and monitoring well SMW-24, located south or southeast of the Univar property, had TCE concentrations of 2.5, 0.65, and 1.2 µg/L, respectively. Low-level concentrations of TCE have been detected intermittently in monitoring wells at the south end of the site in past events.

- **1,1,1-Trichloroethane.** The highest 1,1,1-TCA concentration in groundwater was found at monitoring well SMW-7 (24,000 µg/L). Monitoring wells SMW-4, SMW-5, and SMW-6 contained groundwater with 1,1,1-TCA concentrations of 1,200, 120, and 370 µg/L, respectively. Extraction well EXW-3, located adjacent to the western property line, had the northernmost detectable concentration of 1,1,1-TCA in groundwater (770 µg/L). Monitoring well SMW-15, located west of Univar property, had a 1,1,1-TCA concentration in groundwater of 2.5 µg/L. Monitoring wells SMW-8 and SMW-22, piezometers PZ-4 and PZ-5, and extraction well EXW-2, located in the southwestern portion of the property, contained 1,1,1-TCA concentrations in groundwater of 6.9, 160, 79, 3.2, and 40 µg/L, respectively. Monitoring well SMW-24, located approximately 170 feet southeast of SMW-23, has never had detectable concentrations of 1,1,1-TCA.
- ***Cis*-1,2-Dichloroethene.** The highest *cis*-1,2-DCE concentration in groundwater during the November 2003 event was found at monitoring well SMW-7 (16,000 µg/L). Concentrations of *cis*-1,2-DCE in groundwater above 100 µg/L extend from EXW-2 (620 µg/L), located at the southern edge of the property, to EXW-4a (520 µg/L), located at the northern property boundary. All on-site shallow monitoring wells have detectable concentrations of *cis*-1,2-DCE, with the exception of SMW-17, SMW-21, and SMW-23, all located along the eastern property boundary. *Cis*-1,2-dichloroethene is present in off-site monitoring wells SMW-25 (29 µg/L) and SMW-27 (68 µg/L) to the north, SMW-13 (3.8 µg/L) and SMW-15 (20 µg/L) to the west, and PZ-3 (2.2 µg/L), PZ-5 (3.2 µg/L), and SMW-24 (2.5 µg/L) to the southeast.
- **Vinyl Chloride.** The highest VC concentration in groundwater in November 2003 was found at extraction well EXW-3 (3,000 µg/L), located west of the warehouse. Concentrations of VC above 100 µg/L were also present in monitoring wells SMW-12 (10 µg/L), SMW-26 (1,300 µg/L), PZ-6 (2,700 µg/L), and EXW-4a (770 µg/L) at the north end of the site, near the former solvent recycling area in SMW-4 (680 µg/L), near the drum fill area in well SMW-7 (540 µg/L), near the southern edge of the property in SMW-8 (110 µg/L), SMW-22 (200 µg/L), PZ-4 (1,800 µg/L), and EXW-2 (750 µg/L). Vinyl chloride was present at detectable concentrations in all on-site monitoring wells, with the exception of SMW-1 along the western portion of the property, and SMW-23 in the southeastern corner of the property. Low concentrations of VC were present in off-site wells SMW-13, SMW-15, and SMW-20 (west); SMW-25, SMW-27, and PZ-9 (north); and SMW-24, PZ-3, and PZ-5 (south).

- **Methylene Chloride.** The highest concentration of MC was detected at monitoring well SMW-7 (2,300 µg/L). MC was present above the laboratory detection limit in one other well: EXW-3 (120 µg/L). MC concentrations have declined substantially since the early 1990s, and during the last five years MC has only been detected at significant concentrations in well SMW-7.
- **Total Xylenes.** The highest total xylenes concentration (determined by summing the results for the m-, o-, and p-xylene isomers) in groundwater was found at monitoring well SMW-7 (26,700 µg/L). Detectable levels of total xylenes were present to the south of well SMW-7 in monitoring wells SMW-8 (1,590 µg/L), SMW-22 (481 µg/L), SMW-23 (3.99 µg/L), PZ-4 (4,320 µg/L), PZ-5 (126 µg/L), and EXW-2 (2,120 µg/L). Total xylenes were also detected to the north of SMW-7 in SMW-4 (30 µg/L), SMW-12 (3.1 µg/L), and EXW-3 (178 µg/L). Additionally, two isolated locations, monitoring wells SMW-19 and SMW-21, had total xylenes concentrations of 0.53 µg/L and 0.52 µg/L, respectively. All other off-site and on-site wells did not have detectable concentrations of total xylenes in groundwater.
- **1,1-Dichloroethane.** The highest 1,1-DCA concentration in groundwater was found at monitoring well SMW-7 (4,600 µg/L). Concentrations above 1,00 µg/L were also found at monitoring wells SMW-26 (280 µg/L), PZ-4 (210 µg/L), PZ-6 (280 µg/L), EXW-3 (360 µg/L), and EXW-4a (120 µg/L). Detectable concentrations of 1,1-DCA were present in all on-site monitoring wells except wells SMW-10 and SMW-17. Detectable concentrations of 1,1-DCA were also present in off-site monitoring wells SMW-27 (16 µg/L), SMW-25 (7.4 µg/L), and PZ-9 (6 µg/L) to the north; and SMW-13 (0.5 µg/L), SMW-15 (1.5 µg/L), and SMW-20 (1.7 µg/L) to the west.
- **1,1-Dichloroethene.** The highest 1,1-DCE concentration in groundwater was found at extraction well EXW-3 (1,400 µg/L). Concentrations of 1,1-DCE above 100 µg/L were present in monitoring wells SMW-4 (120 µg/L), SMW-7 (990 µg/L), and PZ-6 (110 µg/L). No off-site monitoring well had a detectable concentration of 1,1-DCE.
- **Toluene.** The highest toluene concentration in groundwater was found at monitoring well SMW-7 (150,000 µg/L). Detectable concentrations of toluene were present to the south and southeast of SMW-7 in monitoring wells SMW-8 (2,000 µg/L), SMW-22 (770 µg/L), PZ-4 (26,000 µg/L), and EXW-2 (5,400 µg/L). Additionally, SMW-12, PZ-6, EXW-3, and EXW-4A, located to the north near the western property boundary, had toluene concentrations of 6.4, 7, 1,600, and 10 µg/L, respectively. Two off-site monitoring wells, located to the west (SMW-19) and south (PZ-5), had low concentrations (0.66 and 5.7 µg/L, respectively) of toluene present in groundwater. All remaining on- and off-site wells did not have detectable concentrations of toluene in groundwater.

Deep Aquifer. The nature and distribution of contaminants in groundwater in the deep aquifer is described in this section. Monitoring wells DMW-1 through DMW-3 (installed in 1988) and DMW-4 and DMW-5 (installed in late 1997) were constructed with the screen intervals located within the transitional silty sand interbeds at the base of the aquitard (discussed in Section 2.4.2.) Monitoring well DMW-2a (installed in late 2000) was constructed with the screen interval located within the coarse gravel and sand aquifer, below the transitional silty sand interbeds. Deep monitoring wells DMW-6 and DMW-7 (installed in September and June 2002, respectively) were constructed with the screen intervals located within the coarse gravel and sand aquifer, below the transitional silty sand interbeds.

As in the shallow aquifer discussion, the following brief description of the concentrations and distribution of the main VOC contaminants present in the deep aquifer at the site is based on the November 2003 groundwater monitoring data. Historical groundwater data at each deep aquifer monitoring well is presented on the constituent versus time plots (see Appendix A). In general, significant concentrations of VOCs were only detected in the DMW-2/2a and DMW-6 areas.

Monitoring well DMW-1, located approximately 75 feet west of the warehouse building, contained low concentrations of 1,1-DCE (1.4 µg/L), 1,1-DCA (1.8 µg/L), *cis*-1,2-DCE (13 µg/L), and TCE (11 µg/L); these results continued the recent upward trends. All other VOCs were not detected above the laboratory detection limit. Monitoring wells DMW-3, DMW-4, and DMW-5, all located east of the loading dock near the eastern property boundary, did not contain detectable levels of VOCs.

Groundwater from monitoring well DMW-2, located with DMW-2a along the rail spur north of the drum fill area, contained detectable concentrations of VC (150 µg/L), 1,1-DCE (21 µg/L), *cis*-1,2-DCE (270 µg/L), *trans*-1,2-DCE (0.54 µg/L), 1,1,1-TCA (16 µg/L), 1,1-DCA (98 µg/L), 1,2-DCA (0.83J µg/L), TCE (120J µg/L), PCE (3.3 µg/L), benzene (12 µg/L), toluene (1.0J µg/L), and total xylenes (0.52 µg/L). The November 2003 VOC concentrations were the highest since November 2002, but were still lower than in 2001 and 2002.

Groundwater from monitoring well DMW-2a contained detectable concentrations of VC (20 µg/L), *cis*-1,2-DCE (9.4 µg/L), 1,1,1-TCA (1.1 µg/L), 1,1-DCA (1.2 µg/L), 1,2-DCA (0.75 µg/L), TCE (6.6 µg/L), PCE (0.63 µg/L), and toluene (0.55 µg/L). The overall trend of concentrations in DMW-2a is downward for all constituents.

Groundwater from monitoring well DMW-6, located to the west of the site on the American Steel property, contained detectable concentrations of VC (0.62 µg/L), 1,1-DCE (6.7 µg/L), *trans*-1,2-DCE (0.84 µg/L), 1,1-DCA (4.9 µg/L), *cis*-1,2-DCE (87 µg/L), 1,1,1-TCA (0.89 µg/L), TCE (46 µg/L), and PCE (4.6 µg/L). The overall trend of concentrations in DMW-6 is downward for all constituents.

Groundwater from monitoring well DMW-7, located on the east side of the loading dock, contained detectable concentrations of four VOCs: dichlorodifluoromethane (0.6 µg/L),

1,2-DCA (0.59 µg/L), TCE (1.8 µg/L), and PCE (4.1 µg/L). The VOC concentrations in DMW-7 are relatively stable.

Based on the information presented in the Deep Aquifer Report (PES, 2004b), including the general deep gravel aquifer groundwater flow direction to the north-northeast, the three years of data from DMW-2a, and the one year of groundwater quality data from DMW-6 and DMW-7, the following preliminary conclusions have been reached regarding the deep gravel aquifer:

- DMW-6 is located upgradient or cross-gradient to the Univar property, indicating that the moderate concentrations of VOCs found in this well may be from a source other than the Univar facility;
- The very low VOC concentrations found in DMW-7 may be due to residual VOCs dragged down during drilling and installation of the well;
- The steady and significant decrease in VOC concentrations in DMW-2a since it was installed three years ago, combined with the elevated and steady VOC concentrations in DMW-2, indicate that DMW-2's steel conductor casing that ran from the ground surface to a depth of 46 feet bgs in the well was likely acting as a conduit for downward transport of shallow aquifer VOCs. DMW-2 was abandoned in January 2005; and
- Groundwater quality and water level monitoring of the deep aquifer monitoring wells consistent with the sampling and analysis plan (ITC, 2001d) continues. Monthly groundwater levels measured in all deep groundwater monitoring wells and quarterly groundwater samples collected from DMW-2a, DMW-6, and DMW-7 will be used to verify the preliminary understanding of the deep aquifer.

2.5.3 Definition of Source Area

Sections 2.5.1 and 2.5.2 describe the nature and extent of contamination in soil and groundwater, respectively. The source of these contaminants was an important consideration during the identification and screening of corrective action technologies and alternatives. It should be noted that there is uncertainty regarding the exact nature of the source area, in large part due to the lack of detailed soil and groundwater sampling results for areas of the site beneath site structures. Specific areas where data is limited that are likely part of the source area include the area beneath the southwest portion of the loading dock (i.e., corrosive tank farm, drum fill shed, and reconditioning room) and beneath the solvent tank farm. The lack of data from these areas increases the uncertainty regarding the definition of the extent of the source areas as well as the estimates of the mass of contaminants present.

Unsaturated Soil. The source area in unsaturated soil was determined by evaluating the following information:

- **Location of documented historical releases.** Figure 2-11 shows the general location of the three documented releases of solvents as reported by the RFI Report (HLA, 1993).
- **Chemical handling operations.** Univar has handled bulk solvents in the following areas: in and around the corrosive tank farm, along the rail spur from just north of the corrosive tank farm to south of the drum fill area, on the dock in and around the drum fill area, at the solvent recycle area, and in and around the solvent tank farm. Chemical handling operations in any or all of these areas may have resulted in *de minimus* losses of solvents to the soil.
- **Existing analytical data for soil and soil gas.** The soil and soil gas data for the site was reviewed and the sample locations with the highest concentration of total VOCs (i.e., greater than 100 mg/kg in soil and greater than 1,000 parts per million by volume [ppmv] in soil gas) were plotted on Figure 2-11.

Based on the areal distribution of these known or potential sources and the analytical data, the approximate source area is located as shown in Figure 2-11. Although there is some uncertainty associated with this area, it is the area most likely to contain the highest concentrations of VOCs that may act as long-term contaminant sources to groundwater and soil gas.

Saturated Soil and Groundwater. The presence of non-aqueous-phase liquids (NAPL) and/or high concentrations of VOCs sorbed onto saturated soil would act as long-term sources of dissolved-phase VOCs in groundwater. Because there are no known releases of solvents directly into the saturated zone, the source of contaminants in saturated soil and groundwater is the downward flow of NAPL through the unsaturated zone, leaching of VOCs by infiltration from the unsaturated soil, or both. Therefore, the areal extent of the source area in the saturated zone is limited by the size of the area shown in Figure 2-11.

It is unlikely that all of the saturated zone in the area shown in Figure 2-11 contains NAPL or high enough concentrations of VOCs sorbed onto soil to act as a long-term source. There is, however, very little sampling data for saturated soil that could be used to help refine the source area in the saturated zone. Furthermore, a review of the boring logs for the monitoring wells installed in the potential source area (e.g., wells SMW-4, SMW-5, SMW-6, and SMW-7) does not suggest the widespread presence of NAPL. A review of the groundwater isoconcentration map for the primary solvents handled at the site (e.g., 1,1,1-TCA, PCE, methylene chloride, TCE, and toluene) show maximum concentrations of greater than 10,000 µg/L centered around monitoring well SMW-7. Concentrations of these same VOCs typically decrease by an order of magnitude or more at the nearest monitoring wells (wells SMW-4, SMW-5, SMW-6, and SMW-8), which are more than 100 feet away from monitoring well SMW-7, making it difficult to determine the exact location of the saturated zone source area.

Therefore, for purposes of the CMS, it will be assumed that the maximum dimensions of the saturated zone source area are the same as for the unsaturated zone source area shown in Figure 2-11. It is very likely, however, that the portions of the saturated zone that contain very high levels of VOCs (e.g., NAPL) are smaller and likely related to the portions of the source area where the primary releases of solvents occurred.

Area and Volume of Soil and Groundwater in Source Area. Based on the definition of the source area shown in Figure 2-11, the source area dimensions are approximately 185 feet by 415 feet (76,800 square feet or 1.76 acres). The total volume of unsaturated soil is approximately 691,000 cubic feet or 25,600 cubic yards (CY), assuming an average ground surface elevation of 34 feet and depth to groundwater of 9 feet.

Assuming that the saturated zone source area extends downward to the top of the aquitard, the average thickness of the saturated zone in this area is approximately 10 to 15 feet (see Figure 2-6). Assuming a 15-foot soil thickness, the resulting volume of saturated soil is approximately 1,152,000 cubic feet or 42,700 CY, and the volume of source area groundwater is 3.4 million gallons (assuming a porosity of 0.40). For the reasons noted above, there is significant uncertainty regarding the estimated area and volume of soil and groundwater in the saturated zone source area.

2.5.4 Contaminant Mass Estimate

During performance of a CMS, it is important to know the total contaminant mass because the duration and cost of the remedy can depend significantly on that calculation. To estimate the contaminant mass, the volume of impacted media and the contaminant concentration in that media must be known or estimated. As noted above, there is significant uncertainty with the delineation of the source area and volume, especially for the saturated zone. There is also uncertainty regarding the horizontal and vertical distribution of contaminants at the scale that may be important when evaluating technologies; there may be sub-areas within the defined source area where contaminants could be present either at much lower or higher concentrations.

As a result of these uncertainties, the total contaminant mass in the source area is highly uncertain. More importantly, very little is known regarding the potential presence and distribution of NAPL, which significantly impacts the overall mass of contaminants and effectiveness of certain technologies. These uncertainties notwithstanding, a range of the mass of contaminants in soil, groundwater, and as NAPL is estimated in Appendix B and summarized below.

Low-Range Estimate. For the low-range estimate of the mass of contaminants in soil, the following assumptions were made:

- **Unsaturated Soil** – The entire source area was assumed to contain an average concentration of total VOCs of 1,000 mg/kg. The estimated contaminant mass in the unsaturated soil is 76,000 lbs.

- **Dissolved Phase** – Assuming an average concentration of total VOCs of 20 milligrams per liter (mg/L), a total of 600 lbs of VOCs are present in the groundwater in the source area.
- **NAPL** – For the low-range estimate, it was assumed that a total of 10,000 square feet of the source area contains residual NAPL. This area was estimated based on the three areas of the documented solvent releases shown on Figure 2-11. For this area, it was further assumed that the entire saturated thickness contains NAPL and that the average percentage of pore space containing NAPL was 3 percent. The low-range calculated mass of residual NAPL is 135,000 lbs.

The total mass in the source area using these low range estimates is approximately 212,000 lbs, or just over 21,000 gallons of VOCs, assuming an average density of 10 lbs/gal.

High-Range Estimate. For the high-range estimate, the following assumptions were made:

- **Unsaturated Soil** – The entire source area was assumed to contain an average concentration of total VOCs of 2,000 mg/kg. Based on these assumptions, the estimated contaminant mass in the unsaturated soil is 152,000 lbs.
- **Dissolved Phase** – Assuming an average concentration of total VOCs of 100 mg/L, a total of 2,900 lbs of VOCs are present in the groundwater in the source area.
- **NAPL** – For the high-range estimate, it was assumed that a total of 22,500 square feet of the source area contains residual NAPL. This area increased from the low range estimate by adding a 20-foot-wide strip along the rail spur within the source area as well as two additional areas (each approximately 50 feet by 50 feet) within the source area where *de minimus* losses from long-term chemical activities resulted in NAPL. Assuming the entire saturated thickness contains NAPL and that the average percentage of pore space containing NAPL was 7 percent, the mass of residual NAPL present in the source area is 709,000 lbs.

The total mass in the source area using these high range estimates is approximately 864,000 lbs, or more than 86,000 gallons of VOCs, assuming an average density of 10 lbs per gallon.

Average Estimate. For purposes of evaluating the performance of different corrective action technologies and preparing cost estimates, an average of the low and high estimates defined above was used. The average contaminant mass is estimated as follows:

- **Unsaturated Soil** – 114,000 lbs.

- **Dissolved Phase** – 1,700 lbs.
- **NAPL** – 352,000 lbs.

The total mass for the average estimate was 468,000 lbs.

2.6 Contaminant Fate and Transport

The previous portions of this section describe the site operational history, hydrogeological conditions, nature and extent of the contaminants present, and the characteristics of the contaminant source area. These factors play important roles in establishing the conditions that control contaminant fate and transport at the site. Understanding these fate and transport processes is an integral part of evaluating potential corrective actions.

2.6.1 Contaminant Sources and Migration Pathways

Sources of Contamination. The releases of chemicals (documented spills and *de minimus* losses) primarily occurred in the bulk chemical handling areas (see Figure 2-11). The combined effect of these releases has created a long-term source of contaminants in the subsurface (Appendix B).

Migration Pathways. When these releases occurred, the chemicals moved downward through the soil as NAPLs under the force of gravity, eventually reaching the water table and the saturated zone. As groundwater moved through source areas, more soluble constituents partitioned into groundwater dictated by the effective solubility of the solvent mixture, generating a plume of dissolved contaminants. Also, volatile constituents in both soil and groundwater partition into the vapor phase and migrate in soil gas.

Over time, the residual NAPL remaining in the subsurface weathers as volatile and soluble components are depleted from NAPL interfaces. These residual NAPLs continue to be a source of contaminants to both groundwater and soil gas.

2.6.2 Contaminant Transport Mechanisms

Physical, chemical, and biological mechanisms in soil and groundwater environments control the transport and migration of contaminants by reducing their mobility, mass, toxicity, volume, or concentration. These *in situ* processes can be divided into nondestructive mechanisms (advection, dispersion, diffusion, dilution, adsorption, volatilization) and destructive mechanisms (chemical or biological stabilization or destruction). The combined action of these processes are often referred to as natural attenuation. These processes, to a greater or lesser degree depending on site conditions, attenuate or control the downgradient migration of contaminants.

Nondestructive Transport Mechanisms. **Advection**, or transport with moving water, is the predominant mechanism for migration of dissolved organic compounds from soil to groundwater, and within the saturated zone itself. In the absence of other factors, contaminants reaching the saturated zone flow at the same speed and direction as groundwater until a stable equilibrium is reached, resulting in very long contaminant plumes.

Dispersion is the small-scale mixing of groundwater as it flows through the soil matrix; dispersion spreads the contaminants outward (both laterally and vertically) from the primary flowpath. Dispersion, in general, does not have a significant effect on controlling contaminant migration.

Diffusion is the process that results in contaminant mixing across the chemical concentration gradient. This process is significant in low permeability zones.

Dilution refers to the introduction of outside sources of water into the subsurface, diluting the contaminants in groundwater. Infiltration of precipitation is the most common type of dilution. At the Univar site, however, nearly the entire site is covered with pavement or structures, greatly limiting infiltration. Another water source that can be important is leaking subsurface utilities (e.g., storm sewers, water lines, steam lines). Although leaking utilities at the site are believed to have resulted in changes in groundwater flow direction and dilution in the early to mid-1990s, these utilities have since been repaired and dilution does not appear to be a significant factor.

Adsorption is the partitioning of contaminants from groundwater onto soil particles, especially soil containing naturally occurring organic material as well as silt and clay. This mechanism is an important factor in attenuating site contaminants through retardation of migration. At the Univar site, the presence of silt and clay materials along the eastern portion of the site bounding the shallow aquifer, and in the aquitard beneath the shallow aquifer, appears to be reducing contaminant migration in these areas.

Volatilization is the partitioning of volatile chemicals from soil and groundwater into the vapor phase (e.g., soil gas). Although a nondestructive mechanism, volatilization does have the effect of reducing contaminant concentrations in soil and groundwater, but at the expense of contaminating soil gas which can migrate to the surface or potentially indoor air spaces.

Destructive Transport Mechanisms. The two general types of destructive attenuation mechanisms are biological and chemical degradation. Of the two, biologically mediated degradation is often more important for organic compounds. As described below, naturally occurring or intrinsic biodegradation is the primary process in the natural attenuation of petroleum hydrocarbons and chlorinated solvents at the Univar site.

2.6.3 Natural Attenuation

The evaluation of natural attenuation at the site is summarized below and described in detail in Appendix C.

Biodegradation of Chlorinated VOCs. Laboratory and field research has shown that chlorinated VOCs, specifically PCE, TCE, TCA, and MC and their daughter products can be biodegraded under aerobic and anaerobic conditions. While some compounds, including vinyl chloride and methylene chloride, are used as sole sources of carbon and energy under aerobic condition, other compounds such as PCE and TCE require specific conditions and cometabolites (such as toluene) to be degraded under aerobic conditions. When these cometabolites migrate along with chlorinated VOCs into an aerobic zone it is likely that significant cometabolic degradation may occur. Under anaerobic conditions, chlorinated compounds are removed through reductive dechlorination. The chlorinated compounds serve as electron acceptors during degradation of organic carbon. At most of the anaerobic sites described above, significant quantities of potential carbon sources are present either as co-contaminants such as toluene (EPA, 1998b) or are produced in the anaerobic zone as fermentation by-products including acetate, formate and others. Reductive dechlorination is the prominent mechanism for removal of chlorinated compounds at the Univar site.

Development of a protocol for the evaluation and documentation of intrinsic degradation of chlorinated solvents was developed by the U.S. Air Force and EPA (Wilson et al., 1996; Weidemier et al., 1998). Natural attenuation has also been selected as part of a remedy for a number of sites. The most comprehensive document was prepared and published by EPA in conjunction with the Air Force Center for Environmental Excellence (AFCEE) and is entitled “Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water” (EPA 1998b). As a result of these and other research studies and demonstrations, intrinsic and enhanced biodegradation of chlorinated aliphatic compounds is being considered as a potential treatment technology for the remediation of chlorinated solvents sites.

Natural Attenuation Guidance Documents. In April 1999, the EPA’s Office of Solid Waste and Emergency Response (OSWER) issued a Final policy document titled “Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites” (OSWER Directive 9200.4-17P). This document was intended to promote consistency in how monitored natural attenuation (MNA) remedies become an aspect of site mitigation and cleanup. It does not, however, provide technical guidance on evaluating MNA remedies.

The “Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water” (EPA 1998b) focuses on technical protocols for data collection and analysis to evaluate MNA through biological processes for remediating all or part of groundwater contaminated with mixtures of fuels and chlorinated aliphatic hydrocarbons.

Data Collection to Support Evaluation of Natural Attenuation. In evaluating natural attenuation processes for the Univar site, the approach and data collected during

monitoring has, in general, been consistent with the technical protocol documents or their precursor technical guidance. The first investigation at the site that focused on evaluating the extent to which biodegradation was occurring was conducted in 1995 (Beak, 1996). Subsequent to this focused investigation, Univar has collected data used to evaluate biodegradation processes during routine groundwater monitoring events. The results of these groundwater monitoring events have been reported to EPA in routine progress reports.

It should be noted that the initial data collection and evaluation efforts in the mid-1990s were conducted independently by Univar following a workplan that was not approved by EPA. The data collected as part of this initial evaluation, and during subsequent routine monitoring is, however, useful for purposes of evaluating general fate and transport processes at the site. Although a significant amount of data has been collected to date, there are portions of the site where data is limited (e.g., beneath the corrosive tank farm and drum fill shed). As a result, conclusions drawn regarding the rate and extent of natural attenuation of contaminants at the site may not be accurate (i.e., actual rates may be lower or higher than predicted).

If in the future MNA is to be considered for implementation at the Univar site, significant additional data collection and evaluation will be required, pursuant to an EPA-approved work plan developed at that time.

Evidence of Natural Attenuation at the Univar Site. There is strong evidence for biologically mediated natural attenuation of the compounds released at the site. Based on the available data, the following general trends have been observed over time:

- Apparent reduction in concentrations of aromatic and chlorinated hydrocarbons along the assumed groundwater flowpath, resulting in generally stable conditions across the plume;
- Apparent reductions over time of VOC concentrations in and downgradient of the primary source area; and
- A strong correlation between:
 - The loss of parent compounds (e.g., PCE, TCE) and the appearance of intermediate daughter compounds (e.g., cis-1,2 DCE, vinyl chloride);
 - The loss of the intermediate daughter products with the appearance of final degradation products (e.g., ethane, ethene, chloride); and
 - The distribution of expected geochemical and biochemical indicators of natural attenuation.

Two key assumptions to the above observations are the groundwater flow path and the definition of the axis of the contaminant plumes. If new data becomes available (e.g., from beneath site structures where existing data is limited) that significantly changes the

assumed groundwater flow directions and/or the orientation of the plume axis, the observations above may require modification.

In order to support these general observations, the site data including hydrogeology, biodegradation reactions, and availability of nutrients and electron donors were evaluated using the Natural Attenuation Screening Protocol worksheet included in the technical protocol (Figure 2 in Appendix C). The worksheet assigns points for geochemical conditions, electron acceptor status, and status of parent and daughter product formation. A cumulative score of greater than 20 indicates strong evidence for anaerobic biodegradation of chlorinated organic compounds. The Univar site scored 32, reflecting the strong evidence of biodegradation based on the available data.

A more quantitative evaluation was also conducted using BIOSCREEN (Rifai, et al., 1995) and BIOCHLOR. These are screening-level analytical models that can be used to evaluate the biodegradation of petroleum hydrocarbons and chlorinated VOCs, respectively. The results of the modeling evaluation for the Univar site are included in Appendix C. Briefly, these models suggest that the assumed dimensions and orientation of the plume, and VOC concentrations within the plume, are likely the result of significant biodegradation. In other words, the models suggest that without biodegradation, the VOC plumes should be longer and contain higher concentrations of VOCs downgradient of the source.

The models were also used to estimate degradation rate constants using VOC concentrations along the apparent groundwater flowpaths to the north and south of the source area. The estimated rate constants for chlorinated VOCs using the available data were generally at or above the high end of those reported in a recent compendium of BIOCHLOR results prepared by AFCEE (Aziz et al, 2000). In the case of PCE and TCE, the calculated rates approached the rates observed in laboratory studies (see Appendix C). While these estimated rates suggest that vigorous degradation is occurring, they also point out that the plume centerline, exact contaminant flow paths, and contaminant distribution are not perfectly defined. The lack of data from beneath site structures is the major limitation of the current data set.

Summary of Natural Attenuation Evaluation. The results of monitoring and modeling provide good evidence that biodegradation of chlorinated and nonchlorinated VOCs released to the subsurface is occurring. Direct evidence for degradation of chlorinated ethanes and ethenes, to a significant extent to completion, is demonstrated by the measurement of daughter products DCE, VC, and ethene. A variety of anaerobic degradation processes including iron-reduction, acetogenesis, and methanogenesis, and to a lesser extent sulfate- and nitrate-reduction, are all likely active in the shallow groundwater (see Appendix C for details). These processes are documented as being involved in the biodegradation of chlorinated and aromatic compounds.

The degradation processes occurring in the contaminant plume appear to have significantly reduced the total mass of VOCs in the groundwater in the shallow aquifer at the site and also appear to have limited, or partially controlled, the distribution of VOCs in the groundwater at and downgradient from the source areas. Specifically, methylene

chloride, toluene, ethylbenzene, xylene, and other organic compounds are being biodegraded, affecting the transport and distribution of these compounds in the shallow groundwater. In addition, the metabolism of these compounds has resulted in the formation of acetic acid which is likely serving as an additional electron donor in the dechlorination of the chlorinated VOCs. Biodegradation of the methylene chloride, toluene, ethylbenzene, and xylene in shallow groundwater may be key in promoting the dechlorination of other chlorinated VOCs.

The dechlorination processes observed at this site are consistent with numerous literature citations. Significantly, the calculated first order rate constants calculated for this site are in some cases more than five times higher than typically reported, suggesting that excellent conditions are present to support biodegradation of contaminants at this site. It must be emphasized that the estimated rate constants for the site may not be accurate given the limitations of the existing data (i.e., actual rates may be lower than predicted). Specifically, high dechlorination activity on PCE, TCE, and 1,1,1-TCA is associated with areas where high concentrations of electron donors such as methanol, ethanol, and acetic acid are available. The detection of ethene in areas downgradient from the source is also consistent with other sites. The degradation processes observed at this site for the nonchlorinated VOCs (e.g., TEX compounds) are consistent with both the literature and field studies. Specifically, high concentrations of the indicators of anaerobic oxidation activity (methane production, increased alkalinity, and low redox potential) are associated with or downgradient of areas where TEX is being consumed.

2.7 Summary of Health and Environmental Assessment

The Health and Environmental Assessment (HEA) was conducted as part of the RFI and is included as Appendix G to the RFI Report (HLA, 1993). The HEA evaluated site soil and groundwater data to select chemicals of potential concern (COPCs) and to identify exposure pathways that were considered complete. The following is a brief summary of the HEA; see the RFI report for a detailed discussion of the methods and assumptions used.

As part of this CMS, certain portions of the HEA have been updated based on data collected subsequent to preparation of the HEA. Specifically, identification of COPCs and reevaluation of exposure pathways and potential receptors were completed in Section 2.8 (Site Conceptual Model) and as part of the development of cleanup levels (CULs) for the site (Section 4.1 and Appendix E).

2.7.1 Selection of Chemicals of Potential Concern

Data for surface soil, subsurface soil, and groundwater were evaluated as part of the HEA CMS. Soil gas data were not evaluated to select COPCs, because they were not considered to be an indication of chemical concentrations in ambient air.

The maximum and arithmetic mean concentrations of detected chemicals were compared to the following standards and criteria promulgated by National EPA, EPA Region 10, and the State of Oregon:

- National RCRA proposed criteria for soil and groundwater;
 - Corrective action levels (ALs)
 - Minimum media protection standards (MPSs)
- EPA Region 10 risk-based concentrations (RBCs) for soil and groundwater;
- Federal Safe Drinking Water Act maximum contaminant levels (MCLs) and MCL goals (MCLGs) for groundwater;
- Oregon MCLs for groundwater; and
- EPA total health-based levels for soil and groundwater (tHBLs).

The specific references for these standards and criteria are provided in Section G4.2 of the HEA. If the maximum or the arithmetic mean concentration exceeded the RBC, the federal MCL, the federal MCLG, the state MCL, or the tHBL for the chemical was selected as a COPC. Although comparisons with ALs and MPSs were performed, these comparisons were not used in selecting COPCs. Any chemical without EPA toxicity criteria was eliminated as a COPC; this was relevant only to metals, since the organic chemicals all had toxicity criteria.

A total of 34 COPCs were selected: 22 VOCs, 7 semivolatile organic compounds (SVOCs), and 5 metals. The COPCs identified in the HEA were considered COPCs for calculation of CULs in the CMS (see Section 4.1).

2.7.2 Identification of Exposure Pathways

The HEA concluded that off-site workers and residents were not likely to contact site chemicals for the following reasons:

- The site was fenced, secured, and paved;
- Groundwater was not used as drinking water;
- Surface water did not exist at the site;
- The distribution of chemicals in groundwater was limited to on-site areas and off-site areas in the immediate vicinity of the site; and
- Current and future corrective measures were expected to capture the chemicals in groundwater before they migrated to downgradient areas.

The HEA concluded that direct contact with groundwater was not a potential exposure pathway for the following reasons:

- Water for the site was provided by public utilities, and no groundwater extraction for any use was known to occur within 1 mile of the site;
- Institutional controls could be used to restrict the future use of groundwater beneath the site for residential, agricultural, or industrial purposes; and
- Corrective measures could be implemented without further evaluation of direct contact pathways. Potential leaching of chemicals from soil to groundwater could be controlled or measured at the site.

The HEA concluded that there were four complete pathways of exposure:

- Inhalation of vapors from soil and groundwater by on-site workers during normal business activities or during maintenance activities above or below pavement and building foundations (e.g., utility lines);
- Inhalation of dust by on-site workers during maintenance activities below pavement or building foundations;
- Incidental ingestion of soil by on-site workers during maintenance activities below pavement or building foundations; and
- Dermal contact with soil by on-site workers during maintenance activities below pavement or building foundations.

2.8 Site Conceptual Model

Since the HEA was completed in 1993, significant additional site characterization of contamination distribution in groundwater has been completed, a soil vapor extraction (SVE) system has been installed beneath portions of the loading dock area, and new guidance on evaluating human health risk and developing risk-based CULs has been issued. The exposure pathways identified in the HEA were re-evaluated to determine whether they were still appropriate and whether additional pathways should be added. Based on this re-valuation, the conceptual site model shown in Figure 2-12 and described below was developed to illustrate the sources, release mechanisms, exposure routes, and potential receptors for site contamination.

Spills and *de minimus* losses from surface operations involving above-ground storage tanks and drums provided the original source of soil contamination. Contaminants were transferred from soil to groundwater via infiltration, percolation, leaching, and possibly by migration of NAPL caused by gravity (i.e., from saturated soil). At present, all of the contaminated soil on site is covered by buildings and pavement, so leaching is no longer

a significant concern. If soil contamination is present above soil saturation concentrations, however, NAPL flow resulting from gravity could still be occurring.

Contaminated groundwater has migrated off site where concentrations of contaminants decrease to nondetectable levels within several hundred feet of the site. Because the regional groundwater flow is toward the Willamette River, groundwater from the site will eventually discharge to the Willamette River approximately 2,200 feet downgradient of the site. Although it is unclear whether site-related contaminants would reach the river, groundwater discharge to surface water is a potentially complete pathway. Future off-site migration of contaminated groundwater will be prevented by ICMs, thereby eliminating the potential for contaminants to discharge to the Willamette River.

VOCs can volatilize from contaminated soil and groundwater, into the unsaturated soil, and ultimately on site to indoor (e.g., office) and outdoor air. In off-site locations, VOCs can volatilize from contaminated groundwater to indoor and outdoor air.

2.8.1 Exposure Pathways and Receptors

Soil. Buildings and pavement prevent contact with contaminated soil on site. If pavement was removed for utility trenching, however, trench workers could be exposed through ingestion of and dermal contact with contaminated soil and inhalation of airborne particulates.

Soil Vapors. Vapors from contaminated soil could be inhaled by outdoor workers on site and could also accumulate in indoor air on site, where they could be inhaled by office workers. If trenching was conducted for utility work on site, vapors could accumulate in the trench where trench workers would inhale them.

Groundwater Vapors. Outdoor workers on site or off site could inhale vapors from contaminated groundwater. Groundwater vapors could accumulate in indoor air on or off site, where office workers could inhale them. If trenching was conducted for utility work on site or off site, vapors could accumulate in the trench where trench workers could inhale them.

Groundwater. If a drinking water well was installed in the vicinity of the site, workers or residents could be exposed to contaminated groundwater by ingestion of, or dermal contact with, the water or inhalation of vapors from the water. It is highly unlikely that such a well would be installed for the following reasons:

- Water for the site and surrounding area is provided by public utilities;
- A beneficial use survey (see Section 2.4.3) identified no current beneficial uses of groundwater within a 1-mile radius of the site. The same survey concluded that there was a very low potential for future beneficial uses of groundwater; and
- Institutional controls can be implemented to restrict the future use of groundwater beneath the site.

As a result, and in concurrence with EPA and DEQ, direct human exposure to groundwater via the drinking water is not a complete exposure pathway and will not be evaluated in this CMS. If groundwater contamination reached the Willamette River, area residents and ecological receptors could be exposed by ingestion of, or dermal contact with, water in the river, or by inhalation of vapors from the water. This scenario is very unlikely considering the ongoing operation of the groundwater ICM.

The site conceptual model shown in Figure 2-12 provides the basis for establishing CULs and goals in Section 4.1.

3 INTERIM CORRECTIVE MEASURES

The existing ICM for the site consists of a pilot scale SVE system. The pilot SVE system has operated on site since August 1992. Additional ICM-related pilot and treatability testing has also been conducted at the site, including SVE system optimization testing, air sparging (AS) pilot testing, and groundwater treatability testing.

A conceptual design for a three well (EXW-2, EXW-3, and EXW-4A) ICM groundwater pump and treat system was completed in April 2000 (ITC, 2000), and a preliminary design was submitted to the EPA in July 2001 (ITC, 2001c). The ICM groundwater system consists of three extraction wells (EXW-2, EXW-3, and EXW-4A), air stripping to treat the groundwater, and resin adsorption to treat the air stripper vapor discharge. The groundwater ICM was constructed during late 2001 and early 2002 and began operations in March of 2002. The pilot testing, SVE ICM operation, and groundwater ICM are discussed below.

3.1 Soil Vapor Extraction ICM

The SVE system was originally installed in 1992 as an interim corrective measure in accordance with the *Interim Corrective Measures Workplan* (VW&R, 1991). The SVE ICM, which has operated since August 1992, consists of four SVE wells (SG-1, SG-2, SG-3, and SG-4). Through March 2002, the SVE ICM had removed an estimated 10,300 pounds of VOC vapors.

Vapors, extracted from the vadose zone using a rotary-lobed blower, were treated in two resin adsorption beds prior to discharge to the atmosphere. The resin beds were periodically regenerated using 270° F steam to desorb VOCs from the resin bed. The desorbed VOCs were collected in liquid form and disposed of off site as a hazardous waste. The SVE ICM resin system provided the design basis for the groundwater ICM resin system. Figure 3-1 provides a schematic of the SVE system layout and shows how the combined SVE vapors are routed to the proposed groundwater ICM treatment building located at the south end of the site; the SVE ICM resin adsorption system is located near monitoring well SG-1.

On April 5, 2002, the SVE ICM wells were connected to the vapor treatment system that is part of the recently constructed groundwater ICM. The typical total vapor extraction rate averages approximately 15 cubic feet per minute (cfm). The SVE ICM has removed an estimated 470 pounds of VOCs between April 5, 2002 and January 31, 2003.

Combined influent SVE VOC concentrations are monitored daily with a PID and combined influent samples are collected monthly for laboratory analysis of VOCs by EPA Method TO-15. The daily PID readings have ranged from 27 to 1,660 ppmv, and monthly laboratory results have ranged from 60 to 375 ppmv since the SVE wells were switched over to the groundwater ICM treatment system. Individual SVE well vapor concentrations (total VOCs) have historically been as high as 10,000 ppmv. Currently, SVE wells are monitored weekly with a PID and individual SVE well vapor samples are collected quarterly. The PID readings have ranged from 0 to 6,450 ppmv, and quarterly laboratory results have ranged from 1 to 1,840 ppmv.

3.2 Pilot Testing

The field pilot study activities were conducted in 1994 and 1995 and included an SVE radius of influence (ROI) study, SVE optimization study, and air sparging study. The purpose of the work was to evaluate the feasibility of SVE and air sparging as potential remedial technologies at the site. The pilot studies were performed generally consistent with Section 3.0 Pilot Scale Studies of the *Final Corrective Measures Study Work Plan* (HLA, 1994). Treatability testing related to the initial groundwater ICM proposed in the early 1990s is discussed in Section 3.3 below.

A detailed discussion of the pilot testing program is included in Appendix D. The following discussion briefly summarizes the pilot testing scope of work and results.

- Scope: Perform SVE ROI of the existing SVE system.

Result: Average ROIs ranged from 41 to 65 feet at wellhead vacuums, ranging from 34 to 69 inches of water column. See Attachment D-3 to Appendix D for a detailed discussion.

- Scope: Optimize VOC removal rates of the existing SVE system.

Result: The results of the SVE optimization testing were inconclusive, but suggest that periodic cycling of the SVE wells may improve system performance. These results should be considered in the design and operation of an expanded SVE system, if constructed. See Attachment D-3 to Appendix D for a detailed discussion.

- Scope: Evaluate if air sparging could be implemented at the site and its effectiveness for groundwater remediation.

Result: The air sparging pilot test was terminated before testing was completed because the vapor monitoring probes clogged and there were of concerns that excessive aeration of groundwater would adversely impact ongoing natural biodegradation. The results of the limited testing that did occur were inconclusive, but suggested that air sparging could increase VOC concentrations at SVE wells. These results should be considered in the evaluation and design

of an air sparging system. See Attachment D-4 to Appendix D for a detailed discussion.

3.3 Groundwater Extraction ICM and Treatability Testing

3.3.1 ICM Evaluation

A groundwater extraction and treatment ICM was originally proposed in the *Interim Corrective Measures Work Plan* (VW&R, 1991). The purpose of this original groundwater ICM was to reduce VOC concentrations along the west side of the Univar property. The initial phase of the ICM was to conduct a treatability study to document the effectiveness of air stripping as a treatment technology capable of achieving discharge limits. As part of this treatability study, Univar installed extraction well EXW-1 and associated conveyance piping, and constructed a water treatment system that included an air stripper.

Concurrent with the design and construction of these groundwater ICM systems, an application for a National Pollution Discharge Elimination System (NPDES) permit was submitted in 1992. In late 1993 and early 1994, Univar conducted the initial treatability tests on the air stripper (see Attachment D-5 in Appendix D). The results of this testing documented the ability of air stripping to reduce VOC concentrations to below anticipated discharge limits for an NPDES permit.

The *Final Corrective Measure Study Work Plan* (HLA, 1994) was issued in early 1994 and included supplemental treatability testing to support issuance of the NPDES permit, as well as pilot study testing designed to assess the hydraulic characteristics of the shallow aquifer and specific performance characteristics of groundwater extraction wells.

Because of issues raised by the City of Portland, the NPDES permit application was rejected and ultimately dropped in late 1994. At this same time, the groundwater flow direction, which previously had been to the west from the source area, began to reverse direction due to repair of a leaking stormwater line (see Section 2.4.2). Also, concentrations of VOCs in wells located along the western portion of the site (e.g., SMW-4, SMW-13, SMW-15) began to decline (see time-trend plots for these wells in Appendix A). For all these reasons, the original groundwater ICM plans along the west property boundary were abandoned.

Following additional groundwater monitoring in 1995 and 1996 to define the effects of the groundwater flow reversal, additional site investigation activities were proposed to support the design of a revised ICM at the north and south ends of the facility. The supplemental investigations are described in the revised workplan for the corrective measures study (EMCON, 1997a). Concurrent with these supplemental investigations, a revised NPDES permit application was submitted to Oregon DEQ in 1997. DEQ issued NPDES permit No. 101613 to the facility on September 18, 1998.

Based on the monitoring results and the findings of the supplemental investigations, Univar conducted an evaluation of ICM alternatives for the north and south ends of the site (EMCON, 1997b). The ICM evaluation report concluded that groundwater extraction and treatment would achieve the desired objective of preventing off-site contaminant migration at the most reasonable cost. Univar submitted an ICM Conceptual Design for groundwater extraction at the south end of the facility (EMCON, 1998b). Following installation and sampling of additional monitoring wells at the north end of the facility, the ICM was expanded to include extraction at the north end of the site near monitoring wells SMW-11 and SMW-26. The groundwater ICM was documented in the *ICM Conceptual Design Report* (ITC, 2000).

3.3.2 ICM Design

The groundwater ICM consists of groundwater extraction, water pretreatment to prevent iron fouling, water treatment using a 500 cfm air stripper, and water discharge to the storm sewer using NPDES permit No. 101613. Air stripper vapor discharge is treated using a resin adsorption system modeled after the system installed as part of the SVE ICM. The original SVE ICM resin system has been taken off-line and the SVE vapors routed to the new resin system. The new resin system is regenerated automatically to minimize VOC breakthrough of the resin beds. The groundwater treatment system is designed to remove 99+ percent of VOCs prior to discharge to the storm sewer. The resin system is designed to remove at least 95 percent of the total VOCs prior to vapor discharge to the atmosphere. The groundwater and vapor treatment systems are sized to allow expansion during implementation of the final corrective measures for the facility. Figure 3-1 shows a plan view layout of the groundwater and SVE ICMs. Figure 3-2 presents a schematic of the ICM treatment equipment building layout.

3.3.3 ICM Startup and Performance

Groundwater Extraction and Treatment. The groundwater ICM was started up on March 12, 2002. The groundwater extraction wells were started on a schedule of one well per week for three weeks. The total pumping rate at startup was 29 gallons per minute (gpm). Evaluation of groundwater level data for the first 4 months of operation indicated that the total groundwater extraction rate could be decreased while still maintaining effective capture of impacted groundwater. Following EPA approval (July 24, 2002 e-mail), the combined groundwater extraction rate was lowered to 19.1 gpm. Subsequent water level monitoring has confirmed effective groundwater capture at the lower pumping rates.

The groundwater ICM system has operated with 70 percent uptime through December 2003. In 2002, a large portion of system down-time occurred in the first three months of operation when the system was down for several weeks for modifications, repairs, and maintenance. From June 2002 through December 2002, the ICM system operated with over 90 percent up-time. In 2003, the system was down for an extended

period of time (approximately 2 months) to permit vapor system modifications. The ICM system operated with nearly 80 percent uptime for the remainder of 2003.

The ICM groundwater system has treated approximately 12.9 million gallons of water with over 99 percent removal of total VOCs. The groundwater extraction system has removed an estimated 1,123 pounds of VOCs between March 12, 2002 and December 31, 2003.

An evaluation of groundwater level monitoring data collected since startup indicates that the groundwater extraction ICM is containing groundwater at the north and south ends of the plume, thereby reducing or eliminating the source of off-site contamination. In the absence of a continuing source, off-site contamination that originated from the Univar site will decrease by natural attenuation processes. Post-startup groundwater monitoring data suggests this process is underway with concentrations of VOCs in SMW-11, SMW-27 and SMW-25, located adjacent to, and immediately downgradient of, EXW-4a at the north end of the facility, decreasing significantly since startup. Well SMW-23 immediately downgradient of EXW-2 on the south end of the facility has shown similar decreases in concentrations.

Vapor Treatment. The resin vapor treatment system has not achieved the design treatment rate of 95 percent of total VOCs during the operating period between March 2002 and December 2003. After resolving some operating issues during the first two months of operation, the treatment system has generally achieved between 75 and 85 percent removal of total VOCs when the resin system mechanical equipment (i.e., boiler, heat exchanger, condenser, resin screen seals, etc.) are operating effectively. However, removal rates less than 50 percent have been observed at times when there have been mechanical malfunctions. The resin system removal rates are calculated based on monthly resin system inlet and outlet vapor samples analyzed for VOCs by EPA Method TO-15.

In an attempt to improve the removal rates and operational effectiveness of the resin system, Univar proposed to EPA to make several major system modifications. After receiving EPA approval for the modifications, Univar shut the ICM system down on February 3, 2003 to implement the changes. The ICM system was restarted on April 9, 2003 and performance data indicated 72 to 93 percent removal until October 2003, when the resin vessel screen seals failed and impacted system performance. The vapor treatment system removal rates decreased to less than approximately 60 percent during the fourth quarter of 2003. In January 2004, the resin system was shut down to replace the screen seals with a new sealant having greater chemical and temperature resistance characteristics. The ICM system was restarted in early February 2004 and performance data is being collected to evaluate the effect of the modifications.

Additional details of the groundwater ICM are discussed in Section 6.2.1 and in the ICM Conceptual Design Report (ITC, 2000) and Section 3.0 of the ICM Preliminary Design Report (ITC, 2001c).

4 CORRECTIVE ACTION SCOPING

The process of developing corrective action alternatives and selecting a final corrective action includes the following major steps:

- Determine cleanup goals and levels;
- Identify applicable regulations and standards;
- Define CAOs;
- Identify general response actions;
- Identify and screen corrective action technologies;
- Develop and evaluate corrective action alternatives; and
- Select the preferred alternative.

This section describes the first three steps, including defining the CAOs. CAOs are media-specific goals that provide the framework for developing and evaluating corrective action alternatives. Section 5 identifies the potentially applicable corrective action technologies and screens them on the basis of the CAOs and site-specific information. Sections 6 and 7 describe the development of a range of potentially applicable corrective action alternatives. The detailed evaluation of the corrective action alternatives is provided in Section 8, and the selection and implementation of the preferred alternative is described in Section 9.

4.1 Media Cleanup Standards

CULs were calculated consistent with EPA Region 10 guidance (EPA, 1998a) and the final Revised Technical Memorandum – Cleanup Level Determination Approach (ITC, 2001a). Calculation of CULs involved the following steps:

- Identification of exposure pathways and endpoints for developing CULs (Section 4.1.1);
- Selection of COPCs (Section 4.1.2);
- Calculation of screening levels (SLs) (Section 4.1.3);

- Selection of chemicals of concern (COCs) (Section 4.1.4); and
- Calculation of CULs for the COCs (Section 4.1.5).

This section summarizes the results of each step; a detailed description is provided in Appendix E. Key uncertainties are discussed in Section 4.1.6, and a more detailed discussion of the uncertainties is provided in Appendix E.

4.1.1 Identification of Exposure Pathways and Endpoints

Soil CULs were developed for the following endpoints:

- Inhalation of vapors in a building by on-site office workers; and
- Soil saturation concentrations to prevent NAPL migration to groundwater due to gravity.

Groundwater CULs were developed for the following endpoints:

- Inhalation of vapors in a building by on-site office workers;
- Inhalation of vapors in a building by off-site office workers; and
- Inhalation of vapors in a trench by off-site trench workers.

CULs were not developed for the following exposure pathways:

- Inhalation of outdoor air on or off site — because inhalation of indoor air is a more protective endpoint;
- Incidental ingestion of and dermal contact with soil and inhalation of vapors in a trench on site — because a proposed institutional control will require protective equipment to control these exposure pathways;
- Potable use of groundwater — because it is highly unlikely groundwater will be used for potable purposes;
- Incidental ingestion of and dermal contact with surface water and inhalation of vapors from surface water in the Willamette River — because the current interim corrective measure controls groundwater transport and prevents the migration of site-related contaminants to the river; and
- Leaching of contaminants from soil to groundwater — because the site is covered by buildings and pavement.

4.1.2 Selection of Chemicals of Potential Concern

A total of 33 COPCs identified in the HEA (HLA, 1993) were retained as COPCs in both soil and groundwater (Table 4-1). No additional screening for COPCs was performed.

4.1.3 Calculation of Screening Levels

For each COPC, SLs based on a 1×10^{-6} excess cancer risk and a hazard index (HI) of 0.1 were calculated for each of the inhalation and soil saturation endpoints identified in Section 4.1.1.

Screening Levels for Vapors from Soil and Groundwater to Indoor Air. SLs were developed using the Johnson and Ettinger model (JEM) for subsurface vapor intrusion into buildings, as implemented in a spreadsheet system provided by EPA (2003). The site-specific spreadsheets (GW-ADV and SL-ADV) were run in the risk-based concentration mode. The SL-ADV spreadsheet was run in the finite source mode, with the bottom of soil contamination defined as the top of the water table.

The values for input parameters in the model are summarized in Appendix E. Soil properties for the unsaturated zone were based on the default parameters provided in the model. Based on review of logs of borings drilled on and off the site, sand was selected as the soil type for off-site areas and loamy sand was selected for the on-site areas. Most of the building properties were set to the default values provided in the model. The on-site building was assumed to be constructed slab-on-grade, while the off-site building was assumed to be constructed with a daylight basement (4 feet deep). The exposure parameters were set consistent with an occupational scenario.

The toxicity values in the EPA spreadsheets were updated to account for modifications to toxicity values that have occurred since the publication of the spreadsheets. Inhalation toxicity values for the COPCs are summarized in Appendix E.

Screening Levels for Vapors from Groundwater to Trench Air. Off-site groundwater SLs were developed for both subchronic (30-day) and acute (1-hour) trenching scenarios, using an equation that combines an estimate of the steady-state emission flux from the trench floor with a simple box model. The trench was assumed to be 7.5 feet deep. Subchronic inhalation toxicity values were derived from chronic values by adjusting for an exposure duration of 30 days. Acute 1-hour inhalation toxicity values were obtained from the literature. All equations and parameter values used in the trench model are presented in Appendix E.

Screening Levels for Soil Saturation and Aqueous Solubility. Soil saturation concentrations were obtained from the JEM spreadsheet.

4.1.4 Selection of Chemicals of Concern

The maximum concentration of each COPC was compared to its corresponding SLs. Maximum concentrations of soil COPCs were obtained from the HEA, combining surface and subsurface soil data. Maximum concentrations of COPCs in the shallow aquifer were obtained from the monitoring data for 2003 (PES; 2003a, b, c and 2004).

If the maximum concentration of a COPC did not exceed any of its SLs in a given medium (soil or groundwater), the chemical was eliminated from further consideration in that medium. Otherwise, the chemical was identified as a COC in that medium.

Twenty COCs were selected for soil (Table 4-1): ten based on vapor inhalation, eight based on both vapor inhalation and soil saturation, and two based on soil saturation only. Thirteen COCs were selected for groundwater (Table 4-1), all based on vapor inhalation. No COPCs exceeded solubility limits in groundwater.

4.1.5 Calculation of Cleanup Levels

Risk-based cleanup levels were developed consistent with the final Revised Technical Memorandum – Cleanup Level Determination Approach (ITC, 2001a) in two steps. In the first step, SLs were adjusted up by a factor of 10 to create “Base CULs,” which correspond to noncancer HIs of 1.0 and cancer risks of 1×10^{-5} for each individual chemical and each exposure pathway. In the second step, risks were distributed across multiple chemicals and, where applicable, multiple exposure pathways to ensure a total HI of 1.0 and a total cancer risk of 1×10^{-5} . CULs were developed for each of the three receptors identified in Section 4.1.3: the on-site office worker, the off-site office worker, and the off-site trench worker.

CULs for the on-site office worker were based on concurrent exposures to vapors from both groundwater and soil, so risks were distributed across both exposure pathways. Eighteen COCs were selected for soil vapors, 13 of which were also the COCs for groundwater vapors. Noncancer risks were distributed across 16 COCs in soil and 13 COCs in groundwater. Cancer risks were distributed across seven COCs in soil and five COCs in groundwater. Exposures to the 13 chemicals that were selected as COCs in both soil and groundwater were counted twice. This is a conservative approach designed to account for concurrent exposures to vapors from both soil and groundwater. The final CUL for each COC was selected as the minimum of its cancer and noncancer CULs. Appendix E shows the proportion of total risk and actual risk assigned to each COC. The final groundwater and soil CULs for each COC for the on-site office worker are shown in Tables 4-2 and 4-3, respectively.

CULs for the off-site office worker and the off-site trench worker were based on inhalation of vapors from groundwater only. Noncancer risks were distributed across the 13 COCs selected for groundwater. Seven of the groundwater COCs are carcinogenic, so cancer risks were distributed across seven COCs. Appendix E shows the proportion of total risk assigned to each COC and the actual risk assigned to each COC. The final

CULs for each COC for the off-site office worker and the off-site trench worker are shown in Table 4-2.

4.1.6 Uncertainty Analysis

The overall CUL development process was designed to be conservative, so CULs are much more likely to be over-protective rather than under-protective. Some of the most important sources of uncertainty are discussed below. Additional discussion of these sources of uncertainty, as well as additional sources of uncertainty, are provided in Appendix E.

For purposes of modeling, the off-site building was assumed to have a daylight basement. Although the standard building practice in the area is slab-on-grade, there is at least one building in the vicinity of the site, a hotel located approximately 2,000 feet west (upgradient) of the site, that has a daylight basement. Assuming a daylight basement is a more protective assumption than slab-on-grade.

Default values, rather than site-specific values, were used for building parameters in the JEM model. The default parameter values might not reflect the actual building conditions on the site, and are probably more conservative than site-specific values.

The model assumes an occupied building lies directly above contaminated soil. With one exception, the buildings on the Univar site that are routinely occupied for extended periods are not located above contaminated soil, and structures in the area of soil contamination are either not enclosed or are not routinely occupied. The exception is the tank farm office located on the loading dock near monitoring wells SMW-7 and DMW-2. This small structure (approximately 12 feet x 20 feet) is routinely occupied, but the floor of this structure is built on pier blocks approximately 6 to 8 inches above the concrete loading dock, not directly in contact as assumed in developing the soil CULs. This 6 to 8-inch gap is open to the air and effectively limits potential migration of vapors from soil or groundwater into this structure. The soil CULs are very conservative for the potential exposures occurring on site at present.

The model also assumes soil contamination is uniformly distributed across the depth specified by the user, which is true for only a portion of the site. The model assumptions maximize the mass of contamination available for volatilizing to indoor air, thus leading to conservative CULs.

The model does not account for transformation processes (e.g., biodegradation and hydrolysis), but site data indicate significant biodegradation is occurring at the site. Assuming no biodegradation leads to conservative CULs.

The JEM groundwater model does not allow the top of the capillary zone to be above the bottom of the building floor, which also means that the capillary zone cannot extend beyond the bottom of the trench. The model assumes that the building floor and trench are in contact with soil. This necessitated setting the trench depth to 7.5 feet, which is likely conservative for most trenching operations. Occasionally, however, deeper

trenches involving dewatering operations might be dug. For trenching operations below 7.5 feet, it is advisable to conduct health and safety monitoring and use appropriate protective equipment to ensure worker protection.

The model assumes all vapors from underlying soils will enter the building, which neglects periods of near-zero pressure differential (e.g., during mild weather when windows are left open). This produces conservative CULs.

The model also treats the entire building as a single chamber with instantaneous and homogenous vapor dispersion, which neglects contaminant sinks and room-to-room variations in vapor concentration due to unbalanced ventilation. Even when groundwater or soil CULs are met, there might be portions of the building that have vapor concentrations higher than intended, as well as portions of the building that have lower vapor concentrations.

The User's Guide for the Johnson and Ettinger Model (EPA, 2003) states that, because of assumptions involving idealized geometry, actual vapor entry rates are expected to be 50 to 100 percent of those estimated by the model. This means CULs are probably conservative.

The maximum soil concentrations detected 12 to 14 years ago during the Phase I through III investigations and documented in the RFI report do not reflect the impacts of the SVE system or natural degradation, so they might overestimate the maximum concentrations currently on site. This would lead to selecting COCs that no longer exceed the SLs. Distributing risks across extraneous COCs forces soil CULs lower and makes CULs more protective.

4.2 Areas Exceeding Groundwater Cleanup Levels

This section identifies the portions of the site where groundwater concentrations exceed the CULs. As described below, there are some portions of the site where contaminant levels in soil and/or groundwater exceed a limited number of CULs, but might not exceed target risk levels. A detailed description of the CUL comparison is described in Appendix F.

The maximum result for each COC detected during the 2003 sampling period for each groundwater sample location, was compared to the groundwater CULs for both on-site and off-site office workers. In some cases, the maximum result was an elevated detection limit. The CULs for the trench worker were not included in this evaluation, because they are much higher than the CULs for the on-site and off-site office workers. Table 4-4 provides a summary of where groundwater cleanup levels are exceeded and provides the number of COCs at each well that exceed the on-site and off site CULs. Figure 4-1 provides a graphical summary and indicates the approximate area exceeding CULs.

Out of 37 sample locations, a total of 28 sample locations have at least one COC that exceeds one or both of the CULs. Nine sample locations had no COCs that exceeded the

off site CUL and 13 locations had no COCs that exceeded the on-site CUL. Fourteen sample locations had exceedances of only one or two COCs, while 10 locations had exceedances for more than six COCs. At SMW-7, all thirteen of the COCs exceed the CULs.

Each of the thirteen groundwater COCs exceeds their CUL at least twice at every sample location. The COCs with the most exceedances are:

- Vinyl chloride: 24 sample locations exceeded the off-site CUL, while 21 locations exceeded the on-site CUL;
- TCE: 18 sample locations exceeded the off-site CUL, while 15 locations exceeded the on-site CUL;
- cis-1,2-DCE: 10 sample locations exceeded both the off site and on-site CULs;
- PCE: 15 sample locations exceeded the off-site CUL, while 9 locations exceeded the on-site CUL; and
- Benzene: 11 sample locations exceeded the off-site CUL, while 9 sample locations exceed the on-site CUL, however, five of the exceedances are due to elevated detection limits.

In general, the locations that have the most COCs that exceed their respective CULs by the largest amount are located in the source area (SMW-4, SMW-5, SMW-6, and SMW-7), along the center of the northern plume (EXW-3, SMW-26, and PZ-6), and along the center of the southern plume (SMW-22, PZ-4, and EXW-2). The locations that have the least number of COCs exceeding CULs are along the east property boundary (SMW-3, SMW-9, SMW-10, SMW-16, SMW-17, and SMW-21) – the majority of these on-site wells had no more than to 1 or 2 COCs exceeding the CULs (Figure 4-1). Out of 11 off-site sample locations, only four sample locations (SMW-15, SMW-27, PZ3, and PZ-9) have one or more COCs that exceeds the off-site CUL. Of these four locations, three (SMW-27, PZ3, and PZ-9) have only one COC that exceeded the CUL.

4.3 Areas Exceeding Soil Cleanup Levels

This section identifies the portions of the site where soil concentrations exceed the soil CULs identified in Table 4-3. As described below, there are some portions of the site where contaminant levels in soil exceed a limited number of CULs, but might not exceed target risk levels. A detailed description of the CUL comparison is described in Appendix F.

For each soil sample location, the maximum result (detected value or elevated detection limit) for each COC across all depths sampled was identified and compared to the soil CUL for the on-site office worker (Table F-2). In Table F-2, a shaded cell indicates a maximum result that exceeds the soil CUL.

Each of the 18 soil COCs exceeds its CUL in at least one sample location, but many of those exceedances are based on elevated detection limits; again, the elevated detection limits were the result of high concentrations of other compounds. For the following six COCs, 10 percent or less of the results that exceeded the CUL were detected values: 1,1-DCA (10 percent); 1,1-DCE (9 percent); 1,2-DCA (0 percent), benzene (8 percent), chloroform (0 percent), and vinyl chloride (5 percent).

Frequency of detection (FOD) is also shown in Table F-2. FOD was calculated based on the data from all sampling depths, not all of which are shown in Table F-2. The calculation of FOD is shown in Table E-13 of Appendix E. The FODs for the following three soil COCs are less than 5 percent: 1,2-DCA (1%), chloroform (0.5%), and vinyl chloride (3%). Typically, chemicals with an FOD less than 5 percent are eliminated from the COC list. The work plan did not state that FOD would be considered so these chemicals were retained as COCs for calculation of CULs.

The vast majority of soil sampling locations (82 of 102) are located in the source area as it is shown in Figure 2-11. These borings typically all have the largest numbers of COCs exceeding their respective CULs and by the largest amounts (Table F-2). Therefore, the primary area exceeding soil CULs on the site is coincident with the source area as shown on Figure 4-2 which also indicates the number of COCs exceeding CULs for the DB and SMW sample locations. Figure 4-2 is large scale, including the entire site; and it shows all the DB and SMW sample locations, but not the surface soil grid locations (designated A through Q) collected during the Phase I and II investigations in the source area. The comparison to CULs results for these surface soil sample locations A through Q were evaluated, however, and were considered when drawing boundary of the area exceeding soil cleanup levels shown on Figure 4-2.

The remaining 20 soil sampling locations (DB-12 through DB-19 and SMW-8 through SMW-21) are located on the southeast property boundary, north and northwest property boundary, and off-site to the west (Figure 4-2). All of these soil sample locations had one or more COCs exceeding their respective CULs; however, many of the exceedances are the result of elevated detection limits. The majority of these sample locations (18 of 20) had 2 or less COCs that exceeded their CULs due to detected concentrations (Figure 4-2 and Table F-2). Nine soil sample locations had no COCs exceeding CULs due to detected concentrations. The two locations having more than two COCs exceeding CULs were DB-12 and DB-15. None of these 20 soil sample locations are beneath existing structures so there is limited potential for office workers to be exposed to vapors originating from these locations.

4.4 Corrective Action Objectives

CAOs form the basis for evaluating potential corrective technologies and actions for the site. CAOs are based on an evaluation of the data from the RFI and on the CULs determined as described above. The focus of the CAOs is protection of human health. No environmental receptors were identified in the HEA or subsequent evaluations.

The following CAOs were proposed in the April 10, 2001, Cleanup Level Determination Approach Technical Memorandum (ITC, 2001a).

4.4.1 Soil Corrective Action Objectives

The CAOs for soil at the Univar facility are as follows:

- Prevent inhalation of vapors by indoor workers on site from soil containing COCs that exceed the applicable CULs so that target risk levels are not exceeded (i.e., HI less than 1 and excess cancer risk less than 1×10^{-5});
- Control incidental ingestion of and dermal contact with soil, and inhalation of particulates and vapors from soil, by trench workers on site by using appropriate monitoring and protective equipment;
- Control migration of NAPL from shallow soil containing COCs above the saturation limit; and
- Minimize the potential for contaminants leaching from soil to groundwater.

4.4.2 Groundwater Corrective Action Objectives

The CAOs for groundwater at the Univar facility are as follows:

- Prevent inhalation of vapors by indoor workers on or off site from groundwater containing COCs that exceed the applicable CULs so that target risk levels are not exceeded (i.e., HI less than 1 and excess cancer risk less than 1×10^{-5});
- Prevent inhalation of vapors by trench workers off site from groundwater containing COCs that exceed the applicable CULs so that target risk levels are not exceeded (i.e., HI less than 1 and excess cancer risk less than 1×10^{-5});
- Control inhalation of vapors from groundwater by trench workers on site by using appropriate monitoring and protective equipment;
- Prevent migration of COCs to the Willamette River; and
- Control or reduce the migration of COCs from on-site contamination source areas, to the extent practicable.

4.4.3 Deep Aquifer

As described in Section 2, Univar implemented a supplemental investigation for the deep aquifer to evaluate the nature and extent of contamination. The initial phase of the deep aquifer investigation sampling and analysis plan (ITC, 2001d) has been completed and

the results were presented in the Deep Aquifer Investigation Report (PES, 2004b). Portions of the deep aquifer investigation will continue to be implemented. Quarterly groundwater levels will be measured in all deep groundwater monitoring wells and quarterly groundwater samples collected from DMW-2, DMW-2a, DMW-6, and DMW-7 will be used to verify the preliminary understanding of the deep aquifer. The development of CAOs for the deep aquifer, if needed, will be deferred until the ongoing investigation activities are completed and the results reported to EPA.

4.5 Applicable Requirements

The following regulations may be applicable to specific technologies or corrective action alternatives. The evaluation of specific regulations will be conducted as necessary during the corrective action alternative development and detailed analysis in Sections 7 and 8, respectively.

Clean Air Act regulates discharge of contaminants to the atmosphere.

Oregon Occupational Safety and Health Code (OAR 437) contains health and safety training requirements for on-site workers. It also contains permissible exposure limits for conducting work at the site.

Oregon Well Construction Rules (OAR 690-240) establish state standards for installing, maintaining, and decommissioning groundwater monitoring and recovery wells at the site.

Safe Drinking Water Act (40 CFR Part 141) establishes the federally enforceable MCLs in public drinking water sources.

Occupational Safety and Health Administration Regulations (29 CFR Part 1910.1200) are administered under the Oregon Occupational Safety and Health Code.

Oregon Water Quality Standards (340-41), which protect aquatic life, can be applicable if discharge of treated water is needed.

Multnomah County local zoning ordinances are used for plumbing or electrical permit requirements.

Oregon Groundwater Quality Protection Rules (OAR-340-40) are used for re-injection or land application of treated water.

Oregon Water Pollution Control Act (ORS 4688 and OAR 340-45) is used for discharge to surface waters under an NPDES permit.

5 IDENTIFICATION AND SCREENING OF CORRECTIVE ACTION TECHNOLOGIES

Corrective action technologies are actions that could be implemented to address, whether alone or in combination with other technologies, one or more of the CAOs listed in Section 4.4. This section describes the process and the results of identifying and screening potentially applicable technologies for achieving the CAOs at the Univar site.

Once identified, the potentially applicable technologies are screened based on the estimated effectiveness, implementability, and overall applicability to the site. An uncertainty rating was included to reflect additional data or technology development that may be needed to demonstrate applicability to the Univar site. In general, technologies with a low overall applicability were screened out, and technologies with a medium or high applicability were retained. Of the 34 technologies considered, 21 were retained.

5.1 Preliminary Technology Identification

The potentially applicable technologies considered for the Univar site are listed in Table 5-1. This list of technologies was compiled based on the nature of the contaminants at the site (VOCs), the environmental media impacted (soil and groundwater), and the types of exposures that need to be addressed (as defined by the CAOs). In general, the technologies considered have been proven effective at full-scale for similar contaminants; technologies still in early stages of development were not considered at this stage. If the existing proven technologies are determined to be unable to achieve the CAOs, newer and less proven technologies may be evaluated.

5.2 Technology Screening Process

The potentially applicable technologies listed in Table 5-1 were screened on the basis of the following criteria:

- **Effectiveness** - technology's ability to contain, control, or treat the site contaminants and meet the CAOs.
- **Implementability** - accounts for constraints or difficulties in implementing the technology and ability to assess and verify the technology's continued effectiveness.

- **Applicability** - relative overall relevance of the technology to the site. Screening of technologies includes an uncertainty rating that reflects the additional data needs or technology development that may be needed to demonstrate the applicability.

The screening process for the potentially applicable technologies is detailed in Table 5-2. The retained technologies are summarized in Table 5-3. Technologies that were considered applicable were retained and are assembled into remedial alternatives in Section 6. Technologies that were not considered to be applicable were not retained for further consideration. The following sections provide a brief summary of the screening process and the retained technologies.

5.3 Vadose Zone Soil Treatment

The objectives of vadose zone soil treatment are stated in Section 4.4. Attaining the CAOs will reduce or eliminate incidental human exposure to soils with concentrations that exceed CULs or target risk levels. Vadose zone soil treatment technologies destroy contamination *in situ* or remove the impacted soil by excavation combined with off-site treatment or disposal. Reducing contaminant concentrations in soil in the source area will minimize migration of contaminants to groundwater, thereby increasing the efficiency of groundwater cleanup.

5.3.1 Limiting Factors

The target soil area and volume generally contained within the source are defined in Section 2.5.3, and shown Figure 2-11. In addition to chemical-specific technology limitations, implementing a soil remedy in the source area is limited by several site constraints.

Buildings and Structures. Buildings or structures (drum fill, drum wash, tank farm office, loading dock, maintenance buildings, tank farms, and other operations areas) occupy greater than 50 percent of the source area. The primary rail spur that serves Univar operations runs north-south through the middle of the source area. These permanent structures and their importance to Univar operations place significant constraints on possible soil remedies (e.g., excavation and installation of conveyance piping).

Subsurface Utilities. Subsurface utilities, including water, gas, electric, and product lines, are located throughout the source area. The approximate locations of known utilities is shown on Figure 5-1 as areas of limited or no construction access. Because of the age of the facility, the location and depth of some subsurface piping and utilities is not known with certainty. The locations of subsurface features will be determined during remedy installation using utility surveys and geophysical tools. The presence of utilities and piping will limit excavation and subsurface installations.

Unknown Contaminant Mass. As described in Section 2.5.4, the total mass of contamination in unsaturated soil is not known. Estimates of the contaminant mass in vadose-zone soil range from 76,000 to 152,000 lbs (Appendix B). The mass of contamination will affect the implementability, effectiveness, and duration of cleanup.

Site-Specific Response Unknown. The effectiveness and implementability of particular soil remediation technologies, and the comparative evaluation of technologies, depends on many site-specific factors that are to some degree unknown. The effectiveness and duration of treatment, and treatment costs, depend on site conditions that impact the remediation processes. For example, the distribution and quantity of contaminant mass within the source area and unidentified heterogeneities in the soil will effect the performance of an SVE system. These unknowns limit the ability to estimate the effectiveness and the cleanup time and cost of a particular remediation approach.

5.3.2 Summary of Technologies

Soil Vapor Extraction. An SVE system typically consists of an extraction network, a vacuum blower, and offgas treatment. Vacuum is applied to extract soil gas. The primary site contaminants are amenable to SVE. Demonstrated performance of the existing SVE system and relatively easy installation and operation make SVE applicable to the site. The location of structures and utilities will limit installation of SVE wells and piping. Limited soil data across portions of the source area and the extent of possible NAPL make design requirements uncertain. SVE was retained.

Thermally Enhanced Soil Vapor Extraction. Hot air, steam, or soil heating are used to enhance desorption, volatilization, and mobility of contaminants by SVE. Limited soil data and the extent of possible NAPL make design requirements uncertain. SVE performance could be improved by thermal enhancement, but the performance improvement and cost-benefit of thermal enhancement are uncertain, and potentially limited. Thermally-enhanced SVE was retained.

Bioventing. Oxygen is delivered by forced air movement or oxygen injection to stimulate aerobic biodegradation. A biological element of an SVE regime would probably result in limited improvement in contaminant removal/destruction, especially for halogenated VOCs. Bioventing was not retained.

Natural Attenuation. Natural processes such as volatilization, biodegradation, adsorption, and chemical reactions, can reduce contaminant concentrations. Demonstrated ongoing biodegradation in groundwater and ease of implementation support possible use. Limited soil data, uncertain degradation rate, and unknown ability to attain low residual concentrations make effectiveness uncertain. Natural attenuation was retained.

***In Situ* Flushing.** Water, or water with amendments, is applied to the soil surface or injected into the ground to flush contaminants into the groundwater. Site constraints

would restrict construction of a distribution network. *In situ* soil flushing was not retained.

Excavation. Impacted soil is excavated and then disposed of or treated. Treatment could be on site or off site by chemical, physical, or biological processes. Site constraints make significant excavation impractical. Limited excavation could be possible during utility work or potential future site improvements. Soil excavation was retained.

5.4 Groundwater Treatment

Attaining the groundwater CAOs would minimize inhalation of vapors from groundwater by indoor workers and control or reduce the migration of COCs from on-site contamination source areas to the extent practicable. The groundwater CAOs are stated in Section 4.4. The specific objectives of the groundwater remedy are to control or reduce contaminant migration from the source area and maintain hydraulic control of the on-site plume. The pending ICMs will prevent off-site migration of groundwater contamination.

5.4.1 Limiting Factors

In addition to chemical-specific technology limitations, implementing an on-site groundwater remedy is limited by several site constraints.

Buildings and Structures. See discussion in Section 5.3.1.

Subsurface Utilities. See discussion in Section 5.3.1.

Unknown Contaminant Mass. As described in Section 2.5.4, the total mass of contamination in saturated soil is not known. Estimates of the contaminant mass, including residual NAPL, in saturated-zone soil and groundwater range from 135,000 to 709,000 lbs of VOCs (Appendix B). The mass of contamination will affect the implementability, effectiveness, and duration of cleanup.

Site-Specific Response Unknown. The effectiveness and implementability of particular groundwater remediation technologies, and the comparative evaluation of technologies, depends on many site-specific factors that are largely unknown. The effectiveness and duration of treatment and the treatment costs depend on site conditions that impact the remediation processes. For example, steam sparging is known to be effective for treating high concentrations of VOCs. However, the zone of influence of a steam injection well, the heat capacity of the treatment zone, the mass of contaminant that must be treated, and site-specific conditions that affect recovery of the VOCs have not been well-characterized at the site. Likewise, bioremediation is known to be effective in treating chlorinated VOCs, and site data show that intrinsic bioremediation is ongoing. However, the ability to enhance the bioremediation process, and site-specific conditions that will affect the rate of bioremediation, are largely unknown. Similar unknowns apply to other groundwater remediation technologies. These unknowns limit the ability to

estimate the effectiveness and the cleanup time and cost of a particular remediation approach.

5.4.2 Summary of Technologies

Groundwater Pumping. Groundwater is pumped to extract contaminants and generate hydraulic gradients that contain the contaminant plume. The proposed ICM will use groundwater extraction to control the plumes at the north and south ends of the site and will be an element of the final remedy. Groundwater pumping could be supplemented by other remediation technologies. Data from this ICM will reduce uncertainty. Groundwater pumping was retained.

Containment Walls. Subsurface barriers, such as sheet piles or slurry walls, are installed to contain impacted groundwater. Severe implementability constraints related to on-site structures and underground utilities make construction of containment walls at the site impractical. Containment walls were not retained.

Injection or Infiltration. Water is injected or infiltrated to manipulate hydraulic gradients to provide hydraulic control or induce groundwater flow toward extraction points. Injection could be coupled with groundwater extraction to promote flushing or enhance biodegradation. Data generated from implementing the ICM will reduce uncertainty. Injection and infiltration were retained.

Reactive Barrier. Permeable reactive barriers are subsurface structures that allow the passage of groundwater while controlling the movement of contaminants. Severe implementability constraints related to on-site structures and underground utilities make construction of reactive barriers at the site impractical. Reactive barriers were not retained.

Biological Treatment. Biological treatment can include several different processes, including natural attenuation, enhanced *in situ* aerobic or anaerobic processes, and aerobic or anaerobic cometabolism.

Natural attenuation can occur by intrinsic biodegradation. Trends in contaminant concentrations and the presence of degradation intermediates demonstrate ongoing anaerobic biodegradation (see Section 2.6.3 and Appendix C). Because natural attenuation is occurring at the site, it will be considered during development of alternatives. Implementation of a formal “Monitored Natural Attenuation” or MNA program, consistent with the applicable EPA guidance and protocols, as part of the overall corrective action will require significant additional data collection. Although it is unlikely that an MNA program will be part of the initial corrective actions at the site, it is possible that after other actions have been successfully implemented (e.g., source control), MNA may play a role in the future. Therefore, Monitored Natural Attenuation was retained for use as a contingent action.

Enhanced aerobic bioremediation refers to addition of oxygen, nutrients, and/or other co-factors to the groundwater to increase the rate of biodegradation. Some of the

predominant site contaminants are not amenable to aerobic biodegradation and the current subsurface conditions at the site are strongly anaerobic. Aerobic bioremediation was not retained.

Enhanced anaerobic bioremediation refers to adding amendments to the groundwater to increase or sustain the rate of biodegradation. Although anaerobic biodegradation rates are typically slow, amendments could enhance the rate of anaerobic biodegradation. Enhanced anaerobic biodegradation was retained.

Cometabolism refers to addition of a cosubstrate to stimulate organisms that fortuitously degrade the target VOCs. Cometabolism can be effective for some chlorinated solvents. Effective cometabolism requires uniform delivery of amendments (e.g., oxygen or cosubstrate). Although additional characterization and technology development would be required, cometabolism could be an effective remediation technology. Cometabolism was retained.

Although data show that natural attenuation is ongoing, the ability to enhance biodegradation is uncertain. Biological systems are complex and additional site characterization and technology development would be required to implement effective bioremediation programs.

Chemical/Physical Treatment. Chemical/physical treatment includes a number of treatment technologies including air sparging, soil heating, thermally enhanced or steam stripping, dual-phase extraction, and *in situ* oxidation.

Air sparging uses injected air to volatilize contaminants. Contaminants sparged from groundwater are typically recovered in the vadose zone by SVE. This technology is generally applicable to site contaminants and implementation constraints are manageable. Sparging would adversely effect ongoing anaerobic degradation processes. Air sparging was retained.

Soil heating uses hot air or other heat sources to enhance desorption, volatilization, and mobility of contaminants. The cost-benefit of soil heating is doubtful, and subsurface utilities and product piping present significant implementability constraints. Soil heating was not retained.

Thermally-enhanced sparging uses steam (steam sparging) to vaporize contaminants. Vaporized components rise to the unsaturated zone and are removed by vacuum extraction. Steam sparging and associated technologies are most effective in medium to high permeability soil. The ground surface at the Univar site is capped with asphalt or concrete, which should enhance pressure and vacuum distribution through the source area. The advantage gained by thermal processes compared to sparging would largely depend on the cost-benefit of a faster cleanup. The cost-benefit of steam sparging could depend on contaminant distribution and the quantity and distribution of NAPL. Steam sparging was retained.

Dual-phase extraction uses vacuum applied to an extraction well or wellpoint to simultaneously extract groundwater, NAPL, and vapors. Both groundwater extraction and SVE are effective and applicable. It is not certain if dual-phase extraction will have an advantage over independent groundwater extraction and SVE. Dual-phase extraction was retained.

***In situ* chemical oxidation** uses a strong oxidizer to oxidize and destroy organic contaminants. Oxidation efficiency depends on the specific chemical (e.g., ethenes are more easily oxidized than ethanes). Risks associated with certain oxidizers (e.g., uncontrolled exothermic reactions, handling strong oxidizers in close proximity to bulk organic solvents) limit applicability. Additional assessment would be required to evaluate the use of this technology. *In situ* oxidation was retained.

5.5 Treatment and Disposal of Extracted Groundwater

Extracted groundwater is typically treated and then discharged to surface water, the sanitary sewer, or reinjected. The ICM system was designed to accommodate additional flows from a final corrective action, if it includes expanded groundwater extraction. The ICM system will include groundwater extraction and treatment to contain the plume and remove contaminant mass. Groundwater pumped by the ICM will be treated above ground using air stripping, and discharged to surface water under an NPDES permit. Details of the ICM treatment system are discussed in the Preliminary ICM Design Report (ITC, 2001c).

5.5.1 Limiting Factors

Potentially limiting factors were considered when evaluating groundwater treatment and disposal options.

Unknown Contaminant Concentration and Total Mass. The concentration of contaminants in extracted groundwater can have a significant impact on the effectiveness and the capital and operating cost of a particular treatment technology.

Chemical-Specific Limitations. Alternative treatment technologies may be effective on some chemicals and not on others. The level of treatment required depends on the initial concentration and the discharge limitations.

Geochemistry. Geochemistry, such as hardness and iron content, can impact treatment efficiency.

5.5.2 Summary of Technologies

Technologies considered for the ICM included air stripping, carbon adsorption, oxidation, and biological treatment. Air stripping was selected for the ICM. The ICM

treatment system will be expanded to accommodate the final remedy. Treated groundwater will be discharged to surface water under an NPDES permit (ITC, 2001c).

Air Stripping. VOCs are stripped from the extracted groundwater by an air stream passed through the water. Aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration. Most site contaminants are amenable to stripping, and air stripping could be implemented in combination with other technologies. High iron in groundwater could impact stripper performance, but iron could be managed by pretreatment. Air stripping was retained.

Carbon Adsorption. Groundwater is pumped through canisters or columns containing activated carbon, and dissolved organic contaminants adsorb to the carbon. Carbon treatment is generally applicable to contaminants other than VC, which adsorbs poorly to carbon. VC would have to be treated by another technology. Granular activated carbon was retained.

Oxidation. Ultraviolet radiation (UV), ozone, and/or hydrogen peroxide are used to destroy organic contaminants as water flows through a treatment vessel. Although the contaminants are amenable to advanced oxidation, operation problems resulting from high iron content of groundwater could cause significant maintenance problems. Oxidation was not retained.

Biological Treatment. A biological reactor is used to treat organic contaminants in extracted groundwater. Bioreactors are not widely used to treat chlorinated solvents found at this site. A bioreactor system would be complex to operate and subject to upset. Biological treatment was not retained.

Discharge Options. After treatment, groundwater is discharged to surface water, the sanitary sewer, or reinjected. Treated groundwater from the ICM will be discharged to the storm sewer under an NPDES permit. Treated groundwater from the final remedy will probably be discharged under the same NPDES permit. ReInjection of treated water to support other technologies (e.g., addition of amendments to enhance biodegradation) was also retained.

5.6 Treatment of Air Emissions

Vapors recovered from the subsurface or generated from groundwater treatment must, to the extent practicable, either be treated to prevent cross-media contamination or to prevent air emissions from exceeding applicable regulatory standards. The ICM system will treat vapor emissions from SVE and air stripping using a synthetic resin adsorption system. The ICM treatment system was designed so it can be expanded to accommodate the final remedy. The resin will be thermally regenerated on site. Details of the ICM treatment system are discussed in the Preliminary ICM Design Report (ITC, 2001c).

5.6.1 Limiting Factors

Unknown Contaminant Concentration and Total Mass. The concentration of contaminants can have a significant impact on the effectiveness and the capital and operating cost of a particular treatment technology.

Chemical-Specific Limitations. Alternative treatment technologies may be effective on some chemicals and not on others. The level of treatment required depends on the initial concentration and the discharge limitations.

5.6.2 Summary of Technologies

Resin Adsorption. Soil vapors and/or air emissions are passed through canisters or columns containing selective synthetic resin to which dissolved organic contaminants adsorb. Resin can be regenerated on site using steam. Resin adsorption is generally applicable, but effectiveness depends on the specific contaminants and resin. Liquids generated by the resin adsorption system would require treatment onsite or disposal at an approved facility. Resin adsorption was retained.

Carbon Adsorption. Soil vapors and/or an air emission stream is passed through canisters or columns containing activated carbon to which dissolved organic contaminants adsorb. When the carbon is saturated with contaminants, it is regenerated or replaced with fresh carbon. Carbon treatment is generally applicable to site contaminants. Carbon use rates are high for some contaminants (e.g., VC). Spent carbon could be sent off site or regenerated on site. Off-site regeneration would be very expensive as a primary removal technology for the anticipated contaminant loads and will not be retained. Although there may be significant RCRA regulatory constraints for on-site regeneration of activated carbon, it was retained to supplement resin adsorption if needed.

Catalytic Oxidation. Soil vapors and/or air emissions are thermally oxidized in the presence of a catalyst, which allows oxidation of organic compounds at lower temperatures (900° to 1,000° F). Emissions from the oxidizer may require scrubbing for removal of acid gasses (e.g., hydrogen chloride). Catalytic oxidation is generally applicable to all site contaminants. There are, however, significant RCRA regulatory constraints on thermal treatment of contaminants generated from RCRA-listed wastes. Liquids generated by the carbon adsorption system would require treatment onsite or disposal at an approved facility. Liquids generated by the scrubber would require the sanitary sewer. Catalytic oxidation was not retained.

Thermal Oxidation. Soil vapors and/or air emissions are thermally oxidized at high temperatures (1,600° to 1,800° F). Supplemental fuels such as natural gas are typically required. Thermal oxidizers can heat gases using open flame or flameless configurations. Emissions from the oxidizer may require scrubbing for removal of acid gasses (e.g., hydrogen chloride). Thermal oxidation is generally applicable to all site contaminants. Capital and operating and maintenance costs are moderate to high and there are

significant RCRA regulatory constraints on thermal treatment of contaminants generated from RCRA-listed wastes. Liquids generated by the scrubber would require the sanitary sewer. Thermal oxidation was not retained.

5.7 Institutional and Engineering Controls

Institutional controls are legal or administrative measures or actions that reduce exposure to hazardous substances. Engineering controls are physical measures that prevent or minimize exposure to hazardous substances or reduce the mobility or migration of hazardous substances. Both institutional and engineering controls are applicable to this site. Institutional controls that were considered would restrict site activities or uses of the Univar site that would result in risk of exposure. For example, site activities or redevelopment of the Univar property would be controlled by deed restrictions until contaminant levels were below acceptable CULs or target risk levels. Engineering controls that were considered for the Univar would prevent direct contact with soils and provide hydraulic containment or control.

5.7.1 Limiting Factors

Legal Constraints. Institutional controls would be applied only to the Univar property. Institutional controls that would limit access or use of off-site property are not warranted or practicable.

Engineering Constraints. Implementation of engineering controls would be limited by site characteristics (e.g., hydrogeology, site structures, and subsurface utilities) that would present engineering constraints.

5.7.2 Summary of Technologies

Water and Land Use Restrictions. Water use restrictions would restrict use of groundwater for domestic or industrial purposes where contaminant concentrations are above regulatory limits. Land use restrictions would limit, or place conditions on, activities such as excavation that could result in exposure, and would specify requirements to limit exposure if land use changes. On-site water and land use restrictions were retained.

Access Restrictions. Access restrictions control exposure during site activities such as excavation or construction. Access restrictions are potentially applicable to on-site soils during future subsurface utility and construction work. Access restrictions were retained.

Engineering Controls. Engineering controls are physical measures that prevent or minimize exposure to hazardous substances or reduce the mobility or migration of hazardous substances. Examples include wellhead treatment, capping of soils, hydraulic control, or control of vapor migration. At the Univar site, there are no domestic or

industrial users of groundwater, so engineering controls such as wellhead treatment are not applicable. Engineering controls to control vapor migration, such as capping, vapor extraction, or maintenance of a paved surface in areas of high vapor concentrations, could be applicable. Engineering controls were retained.

5.8 Summary of Retained Technologies

The technologies retained after the screening process were used in developing corrective action alternatives in Section 6. The retained technologies are listed in Table 5-3.

6 IDENTIFICATION AND SCREENING OF PRELIMINARY CORRECTIVE ACTION ALTERNATIVES

CAAs are combinations of technologies designed to meet the CAOs. The retained technologies from the screening process were assembled into 11 preliminary CAAs that could treat or contain the contaminants in soil and groundwater, protect public health, control the residual contamination source, and reduce contaminant mass. These 11 CAAs were then evaluated (screened) to arrive at a final set of alternatives that would be evaluated in detail. This section identifies the 11 CAAs that were developed, describes the screening process, and lists the retained alternatives. The retained alternatives are developed in greater detail in Section 7, and a detailed analysis is conducted in Section 8.

6.1 Identification of Alternatives

The following 11 CAAs were developed for initial consideration:

Alternative	Technologies	Alternative	Technologies
1	Groundwater ICM, Existing SVE, and Natural Attenuation. Serves as baseline for comparisons.	7	Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area Steam Sparging, and Natural Attenuation.
2	Groundwater ICM, Expanded SVE, and Natural Attenuation.	8	Groundwater ICM, Existing SVE, Expanded Source Area Groundwater Extraction, Source Area Dual-Phase Extraction, and Natural Attenuation.
3	Groundwater ICM, Thermally Enhanced and Expanded SVE, and Natural Attenuation.	9	Groundwater ICM, Existing SVE, Expanded Source Area Groundwater Extraction, <i>In Situ</i> Oxidation, and Natural Attenuation.
4	Groundwater ICM, Existing SVE, Source Area Groundwater Extraction, and Natural Attenuation.	10	Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area <i>In Situ</i> Oxidation, and Natural Attenuation.
5	Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area Groundwater Extraction, and Natural Attenuation.	11	Groundwater ICM, Expanded SVE, Source Area <i>In Situ</i> Enhanced Biodegradation, and Natural Attenuation.
6	Groundwater ICM, Expanded SVE, Source Area Air Sparging, and Natural Attenuation.		

The actions associated with each alternative are listed in Table 6-1. The listed actions support the emphasis and approach of the alternative. For example, Alternative 1 essentially consists of the ICM and natural attenuation and is considered to be the baseline alternative. By contrast, Alternative 7 consists of aggressive treatment and rapid mass removal in the source area by steam sparging.

The source area in the alternatives is the area described in Section 2.5.3. In general, the technologies or actions that comprise the 11 alternatives are those described in Section 5. The following discussion of specific components of the CAAs supplements these descriptions.

6.1.1 Groundwater ICM

The groundwater ICM is a significant element of all the remedial alternatives. The ICM is summarized in Section 3.3; a detailed description is provided in the Preliminary ICM Design Report (ITC, 2001c). The primary objectives of the ICM are to:

- Control and minimize the off-site migration of VOCs in groundwater from the southeast corner and from the north end of the Univar property (EMCON, 1999b and EPA, 1999a); and
- Prevent the transfer of VOCs from one medium to another (EPA, 1999b).

These objectives provide the basis for the conceptual design described in the following sections. Briefly, the groundwater ICM consists of three extraction wells, a groundwater treatment system utilizing air stripping, and a resin-adsorption-based air emission control system. Treated groundwater will be discharged to surface water under the existing NPDES permit.

The startup and initial operation of the ICM has provided data that demonstrates that groundwater extraction achieves containment of the VOC plumes at the north and south ends of the facility and also provides information on mass removal rates associated with the ICM. The ICM was designed and constructed so that it could treat additional groundwater and/or vapors generated from the final corrective action with limited modifications.

6.1.2 Institutional Controls

Institutional controls will be an element of all the corrective action alternatives. Institutional controls are legal or administrative measures or actions that prevent or reduce exposure to hazardous substances. Institutional controls could restrict site activities or uses of the Univar site that would result in risk of exposure. Probable institutional controls are summarized below.

Pavement Maintenance. More than 90 percent of the site, including the source area (Figure 2-11) and other areas with potential soil contamination, are paved with asphalt or

concrete. The pavement surface minimizes infiltration of precipitation and runoff and serves as a cap to minimize incidental exposure to contaminated soil and soil vapors. The asphalt cap will be maintained as necessary to seal cracks and replace pavement that might be removed during future site work. The requirement to maintain the pavement surface will be included in deed restrictions (see below). Inspection and maintenance of the asphalt cap will be described in detail in the implementation plan for the selected corrective action alternative.

Worker-Protection Measures. Workers could contact chemicals of concern during site work such as excavation or trenching related to underground utility installation or maintenance. Specific procedures will be established to ensure that the potential risks to site workers are adequately assessed prior to and during invasive site work and that adequate protective measures (e.g., personal protective clothing, respiratory protection) are used. The requirement for establishing these procedures will be documented in the implementation plan for the selected corrective action alternative and placed in a notice on the deed.

Deed Restrictions and Notices. Deed restrictions and notices will be developed that address the long-term institutional and engineering controls required as part of the final corrective action.

6.1.3 Engineering Controls

Engineering controls will be an element of all the remedial alternatives. Engineering controls are physical measures that prevent or minimize exposure to hazardous substances or reduce the mobility or migration of hazardous substances. Examples of possible engineering controls are listed in Section 5.7.2.

One important engineering control common to all alternatives will be the maintenance of the paved surfaces. The pavement acts as a barrier for vapor migration to the surface and also minimizes infiltration of rainfall.

6.1.4 Natural Attenuation

The natural attenuation processes summarized in Section 2.6.3, and described in detail in Appendix C, will effect the overall performance of the CAAs evaluated in this section. Specifically, natural attenuation will effect contaminant distribution and migration and will also contribute to the overall destruction (i.e., mass removal) of contaminants. As such, the natural attenuation processes ongoing at the site will be evaluated as part of the CAAs, and the potential effects of the other corrective measures in a CAA on these natural attenuation processes evaluated.

The evaluation of natural attenuation as part of CAA development and screening should not be confused with, or construed as, implementation of a formal MNA corrective action. As described in Section 5.4.2, MNA may be considered in the future as a contingent action after source control and other actions have been implemented. When

(and if) an MNA approach is proposed, it will be pursuant to an EPA-approved work plan developed consistent with the EPA OSWER policy document titled "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites" (OSWER Directive 9200.4-17P), or other guidance applicable at the time the work plan is developed.

6.2 Alternative Screening Process

The 11 remedial alternatives listed above were screened to reduce the number of alternatives that will be developed and are evaluated in detail in Sections 7 and 8. Each CAA was evaluated on the basis of effectiveness, implementability, and uncertainty. Effectiveness was determined based on the CAA's ability to meet the following RCRA remedy performance standards (EPA, 1994):

- Protect human health and the environment;
- Attain media cleanup objectives (for current and reasonably anticipated land and resource uses); and
- Remediate the sources of releases to reduce or eliminate further release that might pose threats.

For the Univar site, these three general remedy performance standards are addressed by the CAOs developed in Section 4.4. In addition to effectiveness (i.e., the remedy performance standards), the screening process considered the implementability of each alternative. The initial screening evaluation eliminated alternatives that appeared to have limited ability to achieve the performance standards or have severe implementability constraints (e.g., accessibility issues, safety concerns). Finally, the degree of uncertainty associated with each alternative was evaluated. The screening process is documented in Table 6-2.

The initial screening evaluation included the following tasks:

- Actions associated with each alternative were listed, and technology concepts and process options were considered;
- The effectiveness of each alternative was estimated with respect to site characteristics, contaminant distribution, and the ability to achieve the remedy performance standards (i.e., CAOs and cleanup levels). Ratings of high, medium, or low were assigned to rate effectiveness. A high effectiveness rating means that the alternative would probably achieve the CAOs relatively quickly, whereas a low rating indicates that one or more of the CAOs will not be achieved;
- Implementability was assessed by considering site-specific physical, operational, or regulatory constraints to implementing the alternatives. Ratings

of high, medium, or low were assigned to rate implementability. A high implementability rating means that there are few apparent constraints to implementing the alternative. A low implementability rating means that there are significant constraints to implementing the alternative (e.g., site constraints or health and safety concerns) or there are technology limitations that would be difficult to overcome;

- Uncertainties or data gaps associated with selecting or implementing the technologies were also identified. Ratings of significant, moderate, or insignificant were assigned for uncertainty; and
- The ratings for effectiveness, implementability, and uncertainty were qualitatively compiled into an overall assessment of the alternatives. If an alternative was reasonably effective and there were no overriding limitations or constraints, the alternative was retained for detailed evaluation.

The preliminary screening of alternatives considered the technologies and alternatives in general (e.g., groundwater extraction and treatment and SVE), but did not evaluate the process options in detail (e.g., packed tower stripper with resin adsorption). The preliminary screening did not include evaluation of institutional or engineering controls, which are presumed elements in all of the alternatives (e.g., water- and land-use restrictions, access restrictions, asphalt cap). These details will be considered in the detailed alternative development and evaluation process in Sections 7 and 8.

6.3 Retained Corrective Action Alternatives

Based on the screening process described above, 6 of the 11 CAAs were retained for detailed development and evaluation. The retained CAAs are listed below and summarized in Table 6-3 and discussed in detail in Section 7.

List of Retained CAAs

Alternative	Description
1	Groundwater ICM, Existing SVE, and Natural Attenuation. Serves as Baseline for comparisons
5	Groundwater ICM, Expanded SVE, Source Area Groundwater Extraction, and Natural Attenuation
6	Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area Air Sparging, and Natural Attenuation
7	Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area Steam Sparging, and Natural Attenuation
10	Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area <i>In situ</i> Oxidation, and Natural Attenuation
11	Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area <i>In situ</i> Enhanced Biodegradation, and Natural Attenuation

7 DEVELOPMENT OF RETAINED CORRECTIVE ACTION ALTERNATIVES

This section presents a detailed description of the six retained corrective action alternatives listed in Section 6.3.4. Each retained alternative is discussed in the following section with respect to conceptual design, implementation, effectiveness and performance, estimated cleanup time, and estimated cost. The conceptual design is developed in sufficient detail to conduct the detailed comparative evaluation of the alternatives (Section 8).

The duration of remedy alternatives was estimated using engineering judgment and general knowledge of the remediation technologies. The duration of the cleanup is difficult to predict because numerous site conditions and processes impact the effectiveness of the remediation technologies that make up an alternative. Two of the most important of these conditions are the size of the source area and the mass of contaminants present in the source area (see Appendix B). For cost estimating purposes, the total VOC mass in the subsurface in the source area is estimated to be 468,000 pounds: 114,000 pounds in the vadose zone, 2,000 pounds in the dissolved phase, and 352,000 in the residual NAPL phase.

Even with the use of sophisticated modeling approaches and predictive tools, the cleanup durations can only be predicted within a broad time frame. Therefore, the alternatives were compared on the basis of the estimated relative effectiveness of the technologies and the relative cleanup duration. The evaluation of each alternative includes the effect of ongoing natural attenuation throughout the engineered remediation system operation.

The costs of the remedial alternatives discussed below were developed by accounting for capital costs as well as recurring and future costs. Capital costs include workplans, design reports, other EPA-required documents, and construction to implement the remedy. Recurring and future costs include up to 30 years of groundwater monitoring, operation and maintenance, and reporting.

A contingency cost of 20 percent was added to each alternative to reflect a level of uncertainty in the estimated costs. The contingency on capital cost reflects uncertainty in construction costs. The contingency on recurring and future costs generally reflects uncertainty of the operation and maintenance costs and the duration of the remedy. Even with this 20 percent contingency allowance, these cost estimates should only be considered accurate to a range of minus 30 percent to plus 50 percent of the estimated cost. The cost estimates are rounded to the nearest \$10,000.

Estimated costs for the alternatives are summarized in Table 7-1. Cost details are provided in Tables 7-2 through 7-7. These cost estimates do not include investigation-related project costs to date (i.e., site assessment, routine monitoring, and reporting) or evaluation and implementation of the initial SVE ICM. The estimates do include the construction and operational costs of the groundwater ICM through 2003. The net present value (NPV) for future and recurring costs is based on a discount rate of 7 percent, which is the rate Univar uses for their financial planning. All costs are presented in 2004 dollars.

7.1 Alternative 1: SVE ICM, Groundwater ICM, and Natural Attenuation

Alternative 1 consists of the existing SVE ICM installed in 1992, the groundwater ICM started in March 2002, 30 additional years of combined ICM operations, and natural attenuation. Alternative 1 is not expected to significantly increase the reduction in source area contamination beyond what is naturally occurring and will not be selected as a possible final remedy. However, Alternative 1 has been retained to serve as a baseline comparison for the other alternatives. Figure 7-1 includes a layout of the ICM system.

7.1.1 Alternative 1 Description

SVE ICM

The existing SVE ICM system was originally installed in 1992 as an interim corrective measure generally consistent with the Interim Corrective Measures Workplan (VW&R 1991). The SVE ICM has been operating since August 1992 and removed an estimated 10,300 pounds of VOC vapors through March 2002. Figure 3-1 provides a schematic of the SVE system layout and shows how the combined SVE vapors are routed to the groundwater ICM treatment building located at the south end of the site.

Vapors, extracted from the vadose zone using a rotary-lobed blower, are treated in two resin adsorption beds prior to discharge to the atmosphere. The resin beds are periodically regenerated using 270° F steam to desorb VOCs from the resin bed. The desorbed VOCs are collected in liquid form and disposed of off site as a hazardous waste. The SVE ICM resin system provided the design basis for the groundwater ICM resin system.

On April 5, 2002, the SVE ICM wells were connected to the vapor treatment system that is part of the groundwater ICM. The typical total vapor extraction rate averages approximately 12 cubic feet per minute (cfm). The SVE ICM has removed an estimated 590 pounds of VOCs between April 5, 2002 and December 31, 2003.

Combined influent SVE VOC concentrations are monitored daily with a PID and combined influent samples are collected monthly for laboratory analysis of VOCs by EPA Method TO-15. The daily PID readings have ranged from 4 to 1,660 ppmv, and

monthly laboratory results have ranged from 23 to 581 ppmv since the SVE wells were switched over to the ICM treatment system. Individual SVE well vapor concentrations (total VOCs) have historically been as high as 10,000 ppmv. Currently, SVE wells are monitored weekly with a PID and individual SVE well vapor samples are collected quarterly. The PID readings have ranged from 0 to 6,450 ppmv, and quarterly laboratory results have ranged from 1 to 3,194 ppmv.

Groundwater ICM

The groundwater ICM elements of Alternative 1 were constructed during late 2001 and early 2002 and started operation in March 2002. The groundwater ICM consists of a three well groundwater extraction system (EXW-2, EXW-3, and EXW-4A). The extraction wells are located on the north and south perimeter of the site to hydraulically contain the groundwater plume and prevent migration off site.

Extracted groundwater is pumped to a treatment system on the south end of the facility. The treatment system includes pretreatment using a sequestering agent and filtration to minimize iron fouling and treatment for VOCs using a 500 cfm air stripper. The treated water is discharged to the storm sewer under NPDES permit No. 101613. The vapor discharge from the air stripper is treated using a resin adsorption system modeled after the system installed as part of the SVE ICM. The resin is regenerated automatically to minimize VOC breakthrough of the resin beds. The groundwater treatment system removes VOCs to below permit limits prior to discharge to the storm sewer.

The resin system is designed to remove at least 95 percent of the total VOCs prior to vapor discharge to the atmosphere. As described in Section 3, the resin system has not achieved the design treatment rate of 95 percent of total VOCs during the operating period between March 2002 and December 2003. Univar has implemented several major system modifications in an attempt to improve the removal rates and operational effectiveness of the resin system. The modified ICM system was restarted in early April 2003. In January 2004, the resin system was shut down to replace the screen seals with a new sealant having greater chemical and temperature resistance characteristics. The ICM system was restarted in early February 2004 and performance data is being collected to evaluate the effect of the modifications.

The groundwater extraction ICM collects and treats groundwater at the north and south ends of the plume, thereby reducing or eliminating the source of off-site contamination. In the absence of a continuing source, any off-site contamination that originated from the Univar site beyond the capture zone of the extraction wells will decrease by natural attenuation processes (see below). Additional details of the groundwater ICM are discussed in Section 6.1.3 and in the ICM Conceptual Design Report (ITC, 2000) and Section 3.0 of the ICM Preliminary Design Report (ITC, 2001c).

Natural Attenuation

The natural attenuation processes summarized in Section 2.6.3, and described in detail in Appendix C, will affect the overall performance of Alternative 1 by influencing contaminant distribution and migration and also by contributing to the overall removal of contaminants. Although considered unlikely due to the lack of source control actions, implementation of a formal MNA corrective action may be considered in the future as a contingent action. If an MNA approach is proposed, Univar will prepare a work plan developed consistent with applicable EPA policy and guidance documents at the time the work plan is developed.

Implementation

As stated above, the SVE ICM has been operating since 1992, and the groundwater ICM has been operating since March 2002. The groundwater extraction piping was installed near the eastern property boundary and a moderate amount of contaminated soil was excavated, characterized, and disposed of during construction.

Institutional Controls. Institutional controls are administrative or legal measures, often implemented using restrictive covenants or deed restrictions that would limit potential exposure to site contaminants (see Section 5.7). Institutional controls would be implemented to limit the use of shallow groundwater and restrict or place constraints on site activities such as excavation that could result in exposure. Institutional controls would remain in place until contaminant levels were below acceptable cleanup or target risk levels.

Engineering Controls. Engineering controls are physical measures used to prevent or minimize contact or exposure to contaminants or reduce the mobility or migration of hazardous substances. Engineering controls will be implemented as long as needed to control exposure or limit migration. The primary engineering control for Alternative 1 is maintaining paved surfaces at the site, which act as a cap preventing direct contact and minimizing infiltration.

7.1.2 Effectiveness and Performance

Timeframe

Consistent with EPA guidelines on evaluating costs for long-term corrective actions, a 30-year operating life was used for cost comparison purposes. Due to the nature of Alternative 1, the ICM systems are expected to operate well in excess of 30 years. It is expected that the groundwater extraction wells will ultimately dilute the source plume by drawing it outward toward the extraction wells. Over time, groundwater concentrations will probably initially decrease, then increase due to mobilization of NAPL, and then slowly decrease again over many years or decades of operation. It is expected that extraction well EXW-3 will cut the plume off to the north and over a reasonably short

period of time (i.e., 2 to 3 years), extraction well EXW-4A will be able to be shut off. Continued operation of wells EXW-2 and EXW-3 will be necessary to contain the plume over the long term.

Mass Reduction

An important measure of the performance of an alternative is the mass reduction expected to occur as a result of ICM system operation and ongoing natural attenuation processes. The estimated mass reduction associated with Alternative 1 is described below.

Remediation System Operations. Mass removal in the source area under Alternative 1 will be limited to the amount occurring as a result of natural attenuation processes. The operation of the groundwater ICM remediation systems will not significantly increase removal in the source area since the ICM SVE system is of limited size and the groundwater extraction wells are located outside the source area on the perimeter of the plume. The primary intent of groundwater extraction under the ICM is to control the groundwater gradient to minimize off-site contaminant migration. The primary intent of the SVE system is to remove contaminant mass from the source area.

The Alternative 1 remediation systems will remove contaminant mass from the unsaturated soils along the east edge of the source area, but treatment of possible NAPL zones will be very slow. SVE may improve VOC recovery from the groundwater, but recovery rates will be limited by the size of the system. Based on original ICM SVE system operations and on data collected during the first 21 months of combined groundwater and SVE ICM operation, the expected contaminant mass removal rate is between 700 to 1,200 pounds per year (lbs/yr). The SVE system removed 590 pounds during the first 21 months of operation and is expected to continue to remove approximately 300 to 400 lbs/yr for the entire operating period. The groundwater system removed 1,120 pounds in 21 months of operation. During the initial 4 months of operation, the groundwater system removed VOCs between 3.7 and 6.3 lbs/day. However, since decreasing the groundwater pumping rates in August 2002, the groundwater system is removing VOCs between 1.5 and 2.5 pounds per day. After two or three additional year of operation, the groundwater removal rate is expected to drop to approximately 300 to 600 lbs/yr due to cessation of operation of extraction well EXW-4A and declining concentrations in the remaining extraction wells. Over a 30-year operating period, Alternative 1 ICM system operation is expected to remove approximately 21,000 to 32,000 pounds of mass, not including the 10,000 pounds removed during the first 10 years of the SVE ICM operation.

Natural Attenuation. Based on the analysis of natural attenuation and the associated removal of contaminant mass described in Appendix C, it is estimated that natural attenuation will remove approximately 2,700 lb/yr from the source area. Assuming a constant removal rate, approximately 81,000 pounds of contaminant mass removal is estimated over a 30-year period.

As described in Appendix C, the degradation rates calculated using the available data are at or above the high end of the range of rates reported in literature and are possibly higher than are actually occurring at the site. For purposes of this CMS, however, these rates based on available site data will be used and assumed to be representative of the general order of magnitude of degradation actually occurring.

Alternative 1 Total Contaminant Mass Reduction Estimate. Based on remediation system operation and natural attenuation, the total contaminant mass reduction estimate for Alternative 1 is expected to be between 102,000 and 113,000 pounds over 30 years. This is approximately 22 to 24 percent of the total estimated contaminant mass (468,000 pounds) in the subsurface.

7.1.3 Cost

Alternative 1 serves as a baseline for comparison with the other alternatives. A 30-year operating life was used, and all costs are in 2004 dollars. For estimating purposes, capital costs for this alternative include the actual construction costs for the ICMs (groundwater extraction and SVE), ICM startup and operations and maintenance (O&M) costs incurred through 2003, and writing the CMI workplans and associated reports in 2006.

Future and recurring costs would include the following:

- Routine groundwater monitoring;
- O&M of the ICMs; and
- Performance evaluations and reporting.

Total capital costs for this alternative through 2003 are approximately \$3,000,000. The NPV (assumed 7 percent discount rate) of recurring and future costs over the 30-year project life would be approximately \$3,980,000. The total estimated NPV for this alternative is \$6,980,000 in 2004 dollars. Refer to Table 7-2 for a breakdown of capital and recurring costs for Alternative 1.

7.2 Alternative 5: Groundwater ICM, Expanded SVE, Source Area Groundwater Extraction, and Natural Attenuation

Alternative 5 consists of elements of Alternative 1 plus groundwater extraction and expanded soil vapor extraction in the source area. It is estimated that this alternative would require more than 30 years of operation and natural attenuation. The source area groundwater and soil vapor extraction systems are anticipated to be installed following approximately two additional years of groundwater ICM operation in 2008. Figure 7-2 presents a conceptual layout of the source area wells for Alternative 5. Refer to Appendix B for a description of the source area.

7.2.1 Alternative 5 Description

Expanded Source Area SVE

The expanded SVE system will consist of approximately 24 new SVE wells. Seven SVE wells will be installed between the solvent tank farm and the rail spur, up to 14 wells will be installed on the loading dock, and 3 wells will be installed along the northwest perimeter of the office building. Based on pilot test results and ICM SVE operations, the wells will be spaced on 60- to 80-foot centers. It is estimated that the SVE system will produce between 10 and 40 cfm per well. To balance vapor treatment system size and operation-energy costs, it is likely that the wells will be cycled to maintain an approximate 200 to 400 cfm total vapor flow rate.

It has not been decided at this time whether or not the four existing ICM SVE wells will be abandoned or incorporated into the expanded SVE system. For the purposes of this discussion, however, it is assumed that the existing SVE wells will be abandoned.

The new wells will be connected to the SVE header pipe (installed as part of the existing groundwater ICM construction) by approximately 2,400 feet of pipe. Approximately 1,700 feet of above grade pipe (PVC, HDPE, or steel) will be installed on the loading dock. The remaining 700 feet of pipe will be installed below grade. Several sumps would likely be installed in low spots along piping runs. These sumps would include automatic pumps to pump condensate to the groundwater piping.

Depending on the final configuration of the groundwater extraction and source area SVE systems and the ICM treatment system, the existing blower may be used or a new blower may be required. For purposes of the CMS, it will be assumed that the existing blower will be refitted to increase the flow capacity of the blower to approximately 800 to 1,000 cfm to accommodate the additional flow from the source area. It is anticipated that approximately 600 cfm will be needed to operate the air stripper and 200 to 400 cfm will be required for the source area SVE system.

Vapors extracted from the SVE wells will be treated using the steam regenerable resin system installed as part of the groundwater ICM. Additional resin will be installed in the existing adsorber vessels to increase their contaminant holding capacity. The maximum capacity of the vapor treatment system is largely dependent on the blend of contaminants in the vapor stream. Based on the maximum expected vapor stream concentrations, the treatment system capacity will need to be increased to between 150 to 200 lbs/day of VOCs. Once the final design of the expanded SVE and source groundwater extraction system (see below) is completed, these extraction systems will be installed. During installation and initial startup operations, additional information related to source area contaminant concentrations in both soil vapor and groundwater will be obtained. This additional information will allow for a balancing of the amount of VOCs removed by the extraction systems and the capacity of the vapor treatment system by: (1) reviewing and modifying the design of the ICM vapor treatment as necessary and/or (2) adjusting the

operation of the extraction systems to balance the VOC loading to the vapor treatment system within its performance capacity (i.e., sequencing SVE well extraction).

Source Area Groundwater Extraction

Three new groundwater extraction wells will be installed in the source area, with the groundwater ICM continuing to minimize off-site migration of VOCs from the site. The primary purpose of the source-area groundwater pump-and-treat system will be to remove contaminant mass from the source area and to control groundwater gradients to minimize the migration of contaminants from the source area toward the perimeter ICM wells. Over the long term, operation of source area wells should result in decreasing concentrations in the ICM wells, allowing the perimeter ICM wells to be shut off.

The number of wells was estimated based on the current site conceptual model and data from groundwater pumping tests. It is expected that each of the three groundwater extraction wells would be pumped at approximately 7 gallons per minute (gpm) each to achieve capture of the source area plume. The wells will be connected to the 4-inch diameter groundwater header pipe (installed as part of the groundwater ICM construction) with approximately 850 feet of below grade pipe.

Extracted groundwater would be treated using the ICM groundwater treatment system, which consists of an air stripper, pre-treatment and filtration, and off-gas vapor treatment systems. The ICM systems were designed with adequate capacity to handle additional loading from a source area pump-and-treat system. The air stripper off gas would be treated using the ICM regenerable resin adsorption system. The treated water would be discharged to the storm sewer under the existing NPDES permit.

Natural Attenuation

The natural attenuation processes summarized in Section 2.6.3, and described in detail in Appendix C, will effect the overall performance of Alternative 5 by influencing contaminant distribution and migration and also by contributing to the overall destruction (i.e., mass removal) of contaminants. It is possible that over time, the source control actions and operation of the ICM systems will result in a relatively stable and low concentration VOC plume at the site perimeter. At such time, implementation of a formal MNA corrective action may be considered. If an MNA approach is proposed, Univar will prepare a work plan developed consistent with applicable EPA policy and guidance documents at the time the work plan is developed. The workplan would be implemented after EPA approval.

Implementation

Alternative 5 source area groundwater extraction and SVE will be constructed in 2008 and started up in 2009 after EPA approval of the Corrective Measure Implementation (CMI) Workplan and corrective action design that will be developed during 2006 and

2007. The exact locations of the wells will be based on engineering design as well as field data collected during drilling activities. It is likely that installation of the wells and shallow subsurface piping in the source area will generate contaminated soil during construction. Because of few soil data points (i.e., wells, borings, etc.) in this area, it is difficult to estimate the quantity, if any, that will require disposal as a hazardous waste. It is also unknown at this time whether Level B personal protective equipment will be required during construction. Preconstruction soil screening will be required.

Construction in the source area will be significantly limited by existing facility operations and facility structures on the loading dock and between the railroad spur and the solvent tank farm. Construction work will require close coordination with the facility and may require evening and weekend work to minimize impacts to facility operations, facility worker health and safety, and to protect facility structures. Work in the source area is expected to be significantly slower (and more expensive) than construction in other areas of the facility.

Figure 5-1 shows currently known areas of limited or no construction access in the source area. Constructing a remediation system in these areas will provide significant challenges with respect to protecting existing structures and installing wells and piping in locations optimal for remediation. Working around existing below ground facilities (product piping, steam piping, utilities) will provide significant construction challenges. In some cases, piping may be routed above ground over certain underground features, but this will have to be evaluated on a case by case basis during final design. Existing above ground features (tank farms, drum fill area, truck scale, rail spur, and other structures) will provide hard boundaries for well and piping installation. At this time, it is expected that piping in the loading dock area will be installed on overhead racks or pipe hangers on existing structures.

Institutional Controls. Institutional controls would be placed on the site property title as discussed in Section 7.1.1.

Engineering Controls. Engineering controls for Alternative 5 would be as described in Section 7.1.1.

7.2.2 Effectiveness and Performance

Timeframe

A 30-year operating life was used for cost comparison purposes, but because of the nature of Alternative 5, the source groundwater and SVE systems are expected to operate in excess of 30 years. The first year of operation in 2006 would involve continued operation of the ICM groundwater and SVE systems, preparation of the CMI workplan, and design of the source area groundwater and SVE systems. The source area system would be constructed in 2008 and started up in 2009. The remaining 27 years of project life would entail operating the Alternative 5 remediation system.

The expanded source area SVE system is assumed to operate the remainder of the 30 years. However, it is estimated that groundwater extraction would reduce the source of VOC vapors to the vadose zone, so SVE system operations could be reduced by half after 15 years of operation. A smaller scale SVE system (i.e., fewer operating SVE wells and lower vapor concentrations) would then be operated to control the residual VOC mass in the vadose zone. Source area groundwater wells are expected to operate for 30 years, extraction well EXW-4A would be shut off after 2 to 3 years, extraction rates for wells EXW-2 and EXW-3 would be decreased after 6 years, and these two wells would be shut off after 15 years.

Contaminant Mass Reduction

The estimated mass reduction associated with Alternative 5 is described below.

Remediation System Operations. The SVE and groundwater systems are expected to remove significant contaminant mass in the source area. The SVE system is expected to draw high vapor concentrations in the initial years of operation, and concentrations should steadily drop off as the mass of contamination in the vadose zone decreases. VOC concentrations in groundwater would also gradually decrease over time. The geometry of the contaminant plume and the concentric layout of the groundwater extraction system would probably result in a gradual contraction of the plume. The ICM wells are located on the edges of the contaminant plume where contaminants are primarily by-products of anaerobic biodegradation of the source area contaminants. The source area groundwater extraction wells should cut-off the source plume from the ICM wells. Over time, downgradient VOC concentrations would decrease and the downgradient ICM wells could probably be shut off.

Following removal of contaminant mass in the source area vadose zone, VOC recovery in the vadose zone will be limited by the rate of molecular diffusion from the groundwater. At this point, the primary intent of the SVE system will be to protect indoor air quality at the facility. The groundwater extraction system is expected to continue to remove significant contaminant mass in the source area and will continue to contain the source area by controlling groundwater gradients.

Based on existing SVE ICM system operations and available groundwater data in the source area, the maximum expected contaminant mass removal rate during the first year of Alternative 5 operation is expected to be on the order of 50,000 pounds. It is anticipated that over 80 percent of the contaminant mass will come from the vadose zone in this first year. Over the life of the project, the SVE system is expected to remove approximately 100,000 to 125,000 pounds of contaminant mass, with the majority of the contaminant mass removal occurring in the first 10 years. The groundwater system is also expected to remove approximately 100,000 to 150,000 pounds of contaminant mass. Over a 30-year operating period, Alternative 5 system operation is expected to remove approximately 200,000 to 300,000 pounds of mass.

Natural Attenuation. Based on the analysis of natural attenuation and the associated removal of contaminant mass described in Appendix C, it is estimated that natural attenuation will remove approximately 2,700 lb/yr from the source area. For purposes of the CMS, it is assumed that the expanded SVE and source area groundwater extraction will not affect this removal rate. Therefore, assuming a constant removal rate, approximately 81,000 pounds of contaminant mass removal is estimated over a 30-year period.

As described in Appendix C, the degradation rates calculated using the available data are at or above the high end of the range of rates reported in literature and are possibly higher than are actually occurring at the site. For purposes of this CMS, however, these rates based on available site data will be used and assumed to be representative of the general order of magnitude of degradation actually occurring.

Alternative 5 Total Contaminant Mass Reduction Estimate. Based on remediation system operation and MNA, the total contaminant mass reduction estimate for Alternative 5 is expected to be between 281,000 and 381,000 pounds over 30 years. Approximately 110,000 pounds will be removed in the first five years of operation. This is approximately 60 to 81 percent of the total estimated contaminant mass (468,000 pounds) in the subsurface.

7.2.3 Cost

A 30-year operating life was used for cost calculations. All costs are calculated NPV on 2004 dollars using an assumed 7 percent discount rate. Year 1 of operations is in 2006, with operation of the ICM system (Alternative 1). For costing purposes, it is assumed that Alternative 5 will be designed in 2007, installed in 2008, started up in 2009, and will operate for 27 years (2009 through 2035).

The capital costs would include those of the baseline alternative (Alternative 1), plus the additional cost of designing and constructing the source area groundwater extraction system. Capital costs for Alternative 1 are incurred through 2003. Capital costs for Alternative 5 in addition to Alternative 1 (baseline) include the following:

- CMI Workplan and CMI Design for source-area groundwater and SVE systems in 2007;
- Installing groundwater extraction wells and pumps in 2008;
- Installing SVE wells in 2008;
- Installing conveyance piping and controls in 2008; and
- Adapting the ICM treatment systems (air stripper and vapor treatment) to accommodate increased flow rates in 2008.

Future and recurring costs in addition to Alternative 1 (baseline) would include the following costs starting in 2009:

- Additional sampling and operation and maintenance costs associated with source area SVE and groundwater extraction; and
- Maintenance of the asphalt surface in the source area.

Total capital costs for this Alternative 5 would be approximately \$850,000 in addition to the \$3,000,000 for Alternative 1, for a total capital cost of \$3,850,000 in 2004 dollars. The NPV of recurring and future costs over the 30-year project life would be approximately \$4,990,000. The total estimated NPV for this alternative is \$8,840,000. Refer to Table 7-3 for a breakdown of capital and projected recurring and future costs for Alternative 5.

7.3 Alternative 6: Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area Air Sparging, and Natural Attenuation

Alternative 6 consists of Alternative 5 plus source area air sparging. Alternative 6 includes 30 years of operation and natural attenuation. The source area air sparging, soil vapor extraction, and source area groundwater extraction systems are anticipated to be constructed following approximately two additional years of ICM (Alternative 1) operation in 2008. Figure 7-3 provides a conceptual layout of the source area wells. Refer to Appendix B for a description of the source area.

7.3.1 Alternative 6 Description

Source Area SVE

The expanded SVE system will be consistent with Alternative 5. Refer to Section 7.2.1 for a description of the expanded SVE system.

Expanded Source Area Groundwater Extraction

The expanded source area groundwater extraction system will be consistent with Alternative 5 plus five additional source area wells. The primary purpose of the source-area groundwater pump-and-treat system will be to remove contaminant mass from the source area. The secondary purpose is to control groundwater gradients to minimize the migration of contaminants away from the source area during sparging. Over the long term, operation of source area wells should result in decreasing concentrations in the ICM wells, allowing the perimeter ICM wells to be shut off.

The additional five groundwater extraction wells will require 400 feet of additional groundwater conveyance piping. It is expected that the eight well groundwater extraction system will operate between 3 to 5 gpm per well to control groundwater gradients in the source area. The ICM groundwater treatment system will have the capacity to treat the increased flow rate. During air sparging, increased suspended solids are expected in the groundwater extraction system that may require additional water pretreatment (e.g., settling, filtration, or chemical addition). Refer to Section 7.2.1 for further details of the ICM groundwater system.

Source Area Air Sparging

Alternative 6 expands on Alternative 5 by adding air sparging as a mechanism to remove contaminant mass from below the water table. Air sparging is used in conjunction with source area groundwater extraction. The primary purpose of the air sparging system would be to strip VOCs from the saturated soil and groundwater matrix.

The conceptual spacing of the sparging wells is based on typical data at sites of similar geology. It is estimated that approximately 27 air sparging wells will be spaced on 40 to 60 foot centers and operated at approximately 5 cfm each. The wells will be connected to an air compressor and air dryer at the treatment equipment building via approximately 3,000 feet of piping (1,700 feet below grade and 1,300 feet above grade).

Sparging wells would be screened over a narrow interval near the bottom of the shallow aquifer at sufficient depth below the water table to encourage distribution of the injected air. The air sparging system would be operated at pressures high enough to provide air flow into the groundwater, but below pressures that could fracture the soil or lead to excessive air channeling and short circuiting. Operation of the sparge wells would probably be cycled to improve the efficiency of the sparging system and to minimize long-term preferential flow channels from developing. The sparge zone of influence, well construction details, sparging pressures, cycle duration, and other design considerations would be determined in the field during additional pilot testing and full-scale system monitoring.

The VOCs stripped by sparging would be collected by the SVE system and treated by the steam regenerable resin system described in Alternative 5. The additional resin described in Alternative 5 is expected to be sufficient to treat the increased VOC concentrations in the SVE system. The ICM groundwater pump-and-treat system would control off-site migration of the groundwater plume. Concepts of the expanded SVE and resin vapor treatment systems are discussed in Section 7.2.1.

Natural Attenuation

Alternative 6 will include natural attenuation processes as summarized in Section 2.6.3, and described in detail in Appendix C. Addition of oxygen to the subsurface via air sparging is, however, expected to significantly decrease the rate of natural attenuation for many of the chlorinated VOCs. MNA for the chlorinated VOCs at this site is largely the

result of anaerobic processes. The aeration caused by sparging would create aerobic conditions in the source area which, while drastically slowing the reductive dechlorination of the chlorinated compounds, could increase degradation rates for non-chlorinated VOCs (e.g., toluene). The cometabolic degradation of chlorinated VOCs may also significantly increase. Once sparging has ceased, the anaerobic natural attenuation processes are expected to re-establish themselves over time, likely at a rate significantly less than current.

Implementation

Alternative 6 will be constructed in 2008 and started up in 2009 after EPA approval of the CMI Workplan and corrective action design that will be developed during 2006 and 2007. The exact locations of the wells will be based on engineering design as well as field data during drilling activities. As discussed in Section 7.2.1, construction of Alternative 6 will require close coordination with the facility and may require evening and weekend work to minimize impacts to facility operations, facility worker health and safety, and to protect facility structures. The increased number of subsurface wells for sparging and groundwater extraction, plus all of the additional piping, will increase the difficulty of implementing this alternative. Work in the source area is expected to be significantly slower than construction in other areas of the facility.

Institutional Controls. Institutional controls would be placed on the site property title as discussed in Section 7.1.1.

Engineering Controls. Engineering controls for Alternative 6 would be as described in Section 7.1.1.

7.3.2 Effectiveness and Performance

Timeframe

A 30-year operating life was used for cost comparison purposes, but because of the nature of Alternative 6, the source groundwater and SVE system are expected to operate in excess of 30 years. The first year of operation in 2006 would involve continued operation of the ICM groundwater and SVE systems and design of the source area groundwater, sparging, and SVE systems. The source area systems would be constructed in 2008 and started up in 2009. The remaining 27 years of project life would involve operating the Alternative 6 remediation system.

The air sparging system is expected to operate for approximately 12 years, until readily strippable contaminants are removed from the soil and groundwater matrix. The actual duration of sparging operations will be determined based on contaminant mass removal rates over time compared to system operational costs. The SVE system would be operated full scale when the air sparging system was operating (12 years). A smaller scale SVE system (i.e., fewer operating SVE wells and lower vapor concentrations)

would then be operated to remove residual VOC mass in the vadose zone and contaminant mass volatilizing from groundwater for the remaining 15 years. Source area groundwater wells are expected to operate for 30 years. After air sparging is complete, a reduced number of source area wells would be required for continued contaminant mass removal and gradient control. For cost comparison purposes, it is assumed that extraction well EXW-4A would be shut off after 3 years, extraction rates for wells EXW-2 and EXW-3 would be decreased after 6 years, and these two wells would be shut off after 15 years.

Contaminant Mass Reduction

The estimated contaminant mass associated with Alternative 6 is described below.

Remediation System Operations. The air sparging system would operate concurrent with the expanded SVE system to sparge contaminants from below the water table and capture them in the vadose zone. Therefore, the VOC mass extracted by the SVE system while the air sparging system was operating would be greater than for SVE alone (i.e., Alternative 5). As the readily strippable contaminant mass was removed from below the water table, the VOC vapor concentrations would significantly decrease.

VOC concentrations in groundwater would gradually decrease over time. The geometry of the contaminant plume and the concentric layout of the groundwater extraction system would probably result in a gradual contraction of the plume. The ICM wells are located on the edges of the contaminant plume where contaminants are primarily by-products of anaerobic biodegradation of the source area contaminants. The source area groundwater extraction wells should cut-off the source plume from the ICM wells. Over time, downgradient VOC concentrations would decrease and the downgradient ICM wells could probably be shut off.

Air sparging is commonly used at sites with dissolved phase VOCs and SVOCs that are strippable or can biodegrade aerobically. Most of the chlorinated contaminants at the Univar site do not biologically degrade under aerobic conditions, while many of the non-chlorinated compounds such as toluene can degrade aerobically. Therefore, stripping would be the primary treatment process by sparging, although some biological degradation will occur (see discussion of natural attenuation below). Characteristics such as soil matrix tortuosity, pore space capillary pressures, and air channeling limit the rate of VOC stripping by air sparging. Therefore, significant residual contamination (dissolved and adsorbed on soil particles) could remain below the water table after the benefits of sparging were attained and the sparging system was shut off.

Air sparging in the source area is expected to increase SVE contaminant mass extraction rates by at least 30 percent. Based on existing SVE system operations, available groundwater data in the source area, and a 30 percent increase in removal rates over Alternative 5, the expected contaminant mass removal rate during the first year of Alternative 6 operation is expected to be on the order of 65,000 pounds. It is expected that more than 90 percent of the contaminant mass will be extracted as soil vapors during

the first year of operation. Over the life of the project, the SVE system is expected to remove approximately 180,000 to 220,000 pounds of contaminant mass, with most of the contaminant mass removal occurring in the first 10 years. The groundwater system is also expected to remove approximately 50,000 to 100,000 pounds of contaminant mass. Over a 30-year operating period, Alternative 6 system operations is expected to remove approximately 230,000 to 320,000 pounds of mass.

Natural Attenuation. Air sparging is expected to promote aerobic degradation of non-chlorinated compounds. For practical purposes of this discussion, air sparging is expected to cease reductive dechlorination of chlorinated VOCs. However, aerobic degradation of non-chlorinated compounds may cause fortuitous cometabolic degradation of chlorinated compounds. It is difficult to predict rates of VOC degradation without performing bench and pilot studies, so for the purposes of the CMS, it will be assumed that aerobic degradation will proceed at approximately the same rate of the existing natural attenuation (i.e., 32,000 pounds removed during 12 years of sparging) during operation of the air sparging system.

Following air sparging, the subsurface is expected to revert to anaerobic conditions over time, but overall anaerobic degradation rates are expected to be only a fraction of the existing rates. For the purposes of this contaminant mass removal estimate, it is assumed that natural attenuation processes will contribute to VOC mass removal (following sparging) at 25 percent of the current estimated natural attenuation rate. As a result, natural attenuation is expected to reduce VOC mass by approximately 10,000 pounds in the final 15 years of Alternative 6 operation.

Alternative 6 Total Contaminant Mass Reduction Estimate. Based on remediation system operation, the total contaminant mass reduction estimate for Alternative 6 is expected to be between 270,000 and 360,000 pounds over 30 years. Approximately 150,000 pounds will be removed in the first five years. This is approximately 58 to 77 percent of the total estimated contaminant mass (468,000 pounds) in the subsurface.

7.3.3 Cost

A 30-year operating life was used for cost calculations. All costs are calculated NPV 2004 dollars using an assumed 7 percent discount rate. Year 1 of operations is in 2006 with continued operation of the ICM system (Alternative 1). For costing purposes, it is assumed that Alternative 6 will be designed in 2007, constructed in 2008, started up in 2009, and will operate for 27 years (2009 through 2035).

The capital costs would include those of the baseline alternative (Alternative 1) plus the additional cost of designing and constructing the source area air sparging, vapor extraction, and groundwater extraction systems. Capital costs for Alternative 1 are incurred through 2003. Capital costs for Alternative 6 in addition to Alternative 1 (baseline) include the following:

- Conducting an air sparge pilot test in 2007;
- Designing and reporting for source area sparging, SVE and groundwater extraction in 2007;
- Installing source area air sparging wells in 2008;
- Installing expanded source area SVE wells, groundwater extraction wells, and related conveyance piping and controls in 2008; and
- Upgrading the vapor treatment system per Alternative 5 in 2008.

Future and recurring costs in addition to Alternative 1 (baseline) would include the following:

- Additional sampling and O&M costs associated with source area sparging, SVE, and groundwater extraction;
- Performance monitoring of the air sparge system (i.e., contribution to contaminant mass extraction); and
- Maintenance of the asphalt surface in the source area.

Total capital costs for Alternative 6 would be approximately \$770,000, in addition to the \$3,000,000 for Alternative 1 and \$850,000 for Alternative 5, for a total capital cost of \$4,620,000 in 2004 dollars. The NPV of recurring and future costs over the 30-year project life would be approximately \$5,270,000. The total estimated NPV for this alternative is \$9,890,000. Refer to Table 7-4 for a breakdown of capital and projected recurring and future costs for Alternative 6.

7.4 Alternative 7: Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area Steam Sparging, and Natural Attenuation

Alternative 7 expands on Alternative 5 by adding steam sparging as a mechanism to remove contaminant mass from below the water table in the source area. The VOC vapors transferred into the vadose zone would be collected and treated by the SVE system. An expanded source area groundwater pump-and-treat system would be used to control contaminant migration from the source area caused by the steam sparging. Steam sparging will require that the SVE and groundwater systems be enhanced to withstand the increased temperatures in the source area.

Alternative 7 includes 30 years of operations and monitoring. Alternative 7 is anticipated to be initiated in 2008 after approximately two additional years of groundwater and SVE ICM operations. Figure 7-4 includes a conceptual layout of the source area steam

sparging, SVE, and groundwater extraction systems. Refer to Appendix B for a detailed description of the source area.

7.4.1 Alternative 7 Description

Source Area SVE

The expanded SVE system will be consistent with Alternative 5, plus some enhancements to the well and piping network and additional vapor treatment equipment. Refer to Section 7.2.1 for a description of the expanded SVE system. It is expected that steam sparging will cause significant volatilization of VOCs from the soil and groundwater in the source area and, therefore, the SVE system will be the primary mechanism to remove vapors from the subsurface. A secondary, but important, function of the SVE system will be to maintain control of the hot soil vapors to protect facility structures and protect facility workers, and to prevent migration of soil vapors off site.

SVE wells would be placed to spread the advancing steam front to promote even heating of the unsaturated soil in the source area. The SVE system would operate continuously when the subsurface is heated to properly control soil vapors.

In Alternative 7, the extracted soil vapors in the source area are expected to be on the order of 150° to 250° F and saturated with water vapor. Therefore, the SVE wells and piping will need to be of steel construction to prevent the wells and piping from melting. Above ground piping will need to be insulated to prevent burn injuries to facility workers. Additional moisture knockout sumps and sump pumps will need to be installed to keep SVE lines clear of condensate. Subsurface power and instrument wiring for the SVE system will need to be Teflon coated for high temperature and rated for hazardous environments.

Steam sparging is expected to generate high concentration vapors, so it is anticipated that two additional adsorber vessels and resin will need to be installed to treat extracted soil vapors. A cooling tower and heat exchanger will be installed to cool extracted soil vapors and preheat boiler feed water to decrease boiler fuel costs. The existing Alternative 5 SVE blower will be replaced with a high temperature blower, and it is anticipated that additional chiller capacity will be required to handle the increased resin adsorption vessel regeneration rate. Other vapor treatment system modifications will be determined based on the steam sparging pilot test discussed below.

Expanded Source Area Groundwater Extraction

The groundwater extraction and treatment system will be consistent with the Alternative 6 expanded groundwater extraction system discussed in Section 7.3.1. Steam sparging is expected to increase the dissolved VOC concentrations by liberating residual NAPL in the saturated soil. Therefore, the purpose of the groundwater extraction system will be to

remove contaminant mass and control groundwater gradients to minimize the migration of contaminants during steam sparging.

The source area extraction system is expected to operate at approximately 60 gpm to match the expected steam injection rate (20,000 pounds per hour or approximately 45 gpm) and provide gradient control (15 gpm). The ICM groundwater wells are anticipated to operate at between 15 and 24 gpm.

As stated above in the discussion of the SVE system, groundwater extraction well piping will need to be of steel construction to prevent the wells and piping from melting. Likewise, above-ground piping will need to be insulated to prevent burn injuries to facility workers. Groundwater pumps would be pneumatically actuated (float style or reciprocating), as standard electric submersible pumps are not rated for the expected high temperatures. Installation of a compressed air system, consisting of an air compressor, air dryer, and steel compressed air piping network, will be required. Subsurface power and instrument wiring for the groundwater extraction system will need to be Teflon coated for high temperature and rated for hazardous environments.

Additional water treatment system capacity will be required to handle the increase contaminant load to the water treatment system. It is anticipated that settling tanks, NAPL storage, and a self-backflushing sandfilter will be required to augment water pretreatment. An additional air stripper will likely be required to treat high concentration water. The water effluent from the air stripper would be discharged to the storm sewer under an NPDES permit.

Source Area Steam Sparging

Steam sparging has been typically applied to cleanup sites contaminated with petroleum hydrocarbon such as fuel oils, heavy oils, and creosote. Industry experience and understanding of steam sparging of sites contaminated with PCE and TCE is limited. The processes of contaminant recovery are complex. In general, volatilized contaminants migrate away from injection wells (this would be aided by operation of the SVE system). Contaminants then cool and condense as they migrate into cooler areas, potentially creating a slug of liquid-phase contaminant in front of the advancing steam. DNAPL mobilization could also occur as a result of reduced surface tension and lower viscosities resulting from the high subsurface temperatures. The importance of volatilization, condensation, and displacement depend on site conditions, the nature of the contaminants, and system operation.

Conceptual Design. Steam sparging involves heating of soil and groundwater by injecting steam at a temperature of 250° to 300° F. At the Univar site, steam would be injected through steel wells to volatilize, strip, and mobilize dissolved-phase contaminants and NAPLs. Contaminants that have boiling points lower than the steam temperature or the resulting subsurface temperature would be volatilized. Contaminants that have boiling points higher than the steam would have their vapor pressures increased by the increased subsurface temperatures and would also tend to be volatilized. NAPLs

would have their viscosity and density lowered because of the subsurface heat, which would promote mobilization.

The steam sparging system in this alternative consists of up to 14 steam sparging wells installed on approximately 80-foot centers in the source area. The steam sparging wells would be connected by a network of steel piping headers and laterals to inject steam below the water table. Piping would be steel construction and insulated. Several expansion joints would be installed to maintain pipe integrity during heating and cooling cycles. Steam traps would be installed throughout the piping network to remove condensed steam (i.e., water) from the system and decrease pipe pressure losses.

Steam would be produced by 20,000-lb/hr boiler. The steam boiler would augment or replace the 1,000 lb/hr boiler installed for the ICM treatment system. Potentially the ICM boiler could be used for facility operations or sold if it is not needed for steam sparging system operations.

Operation Strategy. After an initial heating period of several months, the steam sparging system would be operated cyclically (“pulsed”) at temperatures and pressures to keep the subsurface at a constant target temperature and conserve energy. The pulsed operation would create thermal cycles that enhance contaminant recovery by the mechanisms described above. The operating cycle would be adjusted empirically during testing, startup, and operation. Typical steam sparging system operations consist of a three- to six-month initial heating period followed by “pulsed” operation for the life of the steam sparging period. To optimize the size of the boiler required for steam sparging, a typical scenario is to pulse the steam sparge system network by rotating between sparge wells.

Typically, steam sparging wells are constructed so they could operate as steam sparging wells or as air sparging wells. The air sparging wells would be operated as needed to optimize removal of source area contaminants from below the water table when the steam sparging system is off. For this analysis, all steam sparging and air sparging wells would be interchangeable, so that the wells could be used for either steam sparging or air sparging. Because of the somewhat unpredictable nature of steam sparging, it is important to build in system flexibility and redundancy to maximize system performance and control. The air compressor installed to operate the groundwater extraction pumps is assumed to be able to operate the air sparging wells as well.

Temperature Monitoring Network. Ability to monitor heat distribution is an important element of steam sparging operation. A network of monitoring points would be installed to monitor the subsurface temperature in the source area. Temperature data would be used to optimize both steam sparging operation and recovery operations (SVE and groundwater pump-and-treat). A typical temperature monitoring point consists of three thermocouples installed at various depths in a single borehole (i.e., top of the aquitard, average groundwater table, and vadose zone) to provide a three-dimensional view of the heat distribution in the source area.

Pilot Testing. A pilot test would be performed to determine the feasibility and effective influence area of steam sparging. The pilot test requires installation of all components of the steam sparging system discussed above, only on a smaller scale. Typically, a steam sparging pilot test is operated for two months to one year, depending on the size of the pilot test area. For costing purposes, it is estimated that the steam sparging pilot test will be operated for two months.

The results of the steam sparging test will provide design data to size the steam boiler, vapor treatment system, and water treatment system. Pilot test data will also be used to locate sparging wells, SVE wells, and groundwater extraction wells and estimate their respective recovery rates.

Natural Attenuation. Alternative 7 will include natural attenuation processes as summarized in Section 2.6.3, and described in detail in Appendix C. However, the high temperatures created by steam sparging are expected to substantially reduce biological activity, essentially eliminating the occurrence of any biological attenuation processes. Once sparging has ceased, these natural attenuation processes are expected to slowly re-establish themselves. For purposes of this alternative, however, it will be assumed that no additional biological degradation will occur in the source area after steam sparging commences.

Implementation

Alternative 7 will be implemented in stages. In 2008, after approximately two additional years of groundwater ICM operation, the expanded source area groundwater and vapor extraction systems will be installed. Concurrent with or following installation of these systems, the pilot steam sparging system will be installed. The steam sparging pilot test will be conducted in 2007. The final steam sparging system will be installed in 2009, and operations will begin in 2010.

As discussed in previous alternatives, the exact locations of the wells will be based on engineering design as well as field data compiled during drilling activities. Steam sparging system installation will require two major construction events (in 2008 and 2009), which will require significant coordination with the facility, as discussed in previous alternatives. The number of injection and extraction wells, and the enhancements to both new and existing piping systems, will make implementing steam sparging more difficult.

Institutional Controls. Institutional controls would be placed on the site property title as discussed in Section 7.1.1.

Engineering Controls. Engineering controls for Alternative 7 are as described for Alternative 1. Additional controls designed to minimize the impacts of high temperature equipment and piping will also be implemented.

7.4.2 Effectiveness and Performance

Timeframe

A 30-year operating life was used for cost comparison purposes. The first two years of operation (2006 through 2008) would be continuing operations of the ICM groundwater and SVE systems. The fourth year of operation (2009) would be operating the Alternative 5 source area groundwater and SVE systems. The steam sparging system would be started in 2010. The remaining 26 years of project life would be operating the Alternative 7 remediation system.

The steam sparging system would operate for three years, until significant contaminant mass removal was attained. After three years, it is expected that the cost for steam sparging relative to contaminant mass removal would have increased significantly. However, depending on matrix constraints and removal efficiency, additional years of steam sparging may be required. Following steam sparging, air sparging will replace steam sparging for two years, and all sparging would cease for the remainder of the project. The SVE system would operate full scale until sparging (steam and air) is completed (6 years). For costing purposes, it is assumed that a smaller scale SVE system (i.e., fewer operating SVE wells and lower vapor concentrations) would then be operated to remove residual VOC mass until year 15. Source area groundwater wells are expected to operate for 30 years. However, after sparging is complete, a reduced number of source area wells would be required to contain the source area by groundwater gradient control. For cost comparison, extraction well EXW-4A would be shut off after 3 years, and wells EXW-2 and EXW-3 would be shut off after 15 years.

Contaminant Mass Reduction

The estimated contaminant mass reduction associated with Alternative 7 is described below.

Remediation System Operations. The steam sparging system would operate concurrent with expanded SVE system to sparge contaminants from below the water table and capture them in the vadose zone. Therefore, the VOC mass extracted by the SVE system while the steam system was operating would be greater than for SVE alone (i.e., Alternative 5) or air sparging with SVE (i.e., Alternative 6). As the readily strippable contaminant mass is removed from below the water table, the VOC vapor concentrations would significantly decrease.

Because of the aggressive nature of steam sparging, source area VOC concentrations (groundwater and soil) are expected to decrease significantly in three years of operation. The geometry of the contaminant plume and the concentric layout of the groundwater extraction system would probably result in significant contraction of the plume. The ICM groundwater extraction wells are located on the edges of the contaminant plume, where contaminants are primarily by-products of anaerobic biodegradation of the source area contaminants. The source area groundwater extraction wells should cut-off the

source plume from the ICM wells. Over time, downgradient VOC concentrations would decrease and the downgradient ICM wells could probably be shut off.

Because of the heat applied during steam sparging, this technology is not generally limited by soil matrix characteristics such as tortuosity, pore space capillary pressures, and channeling that is typically seen in air sparging systems. However, high groundwater recharge rates can limit steam sparging effectiveness. Because of the costly nature of steam sparging (high utility costs), steam sparging systems are typically shut off when the cost of sparging outweighs the benefit of sparging. For the purposes of the CMS, it is assumed to be after three years of steam sparging system operation.

In the first year of steam sparging system operation, it is not unreasonable to assume that between 100,000 and 200,000 pounds of contaminant mass will be removed. By the end of steam sparging operations, it is expected that 80 percent of the total contaminant mass will be removed via the source area SVE and groundwater extraction systems. An additional 10 to 15 percent of the contaminant mass is expected to be removed by operating the air sparging system (2 years), SVE system (2 years), and groundwater extraction system (23 years). Over a 30-year period, Alternative 7 operations are expected to remove between 420,000 and 450,000 pounds of mass.

Natural Attenuation. The high temperatures created in steam sparging are expected, for practical purposes, to sterilize the subsurface and eliminate natural attenuation for the duration of this alternative. For the purposes of this contaminant mass removal estimate, it is assumed that natural attenuation will not contribute to VOC mass removal in Alternative 7.

Alternative 7 Total Contaminant Mass Reduction Estimate. Based on remediation system operation, the total contaminant mass reduction estimate for Alternative 7 is expected to be between 420,000 and 450,000 pounds over 30 years. Approximately 240,000 pounds will be removed after the first five years. This is approximately 90 to 95 percent of the total estimated contaminant mass (468,000 pounds) in the subsurface.

7.4.3 Cost

A 30-year operating life was used to calculate costs. All costs are calculated NPV 2004 dollars using an assumed 7 percent discount rate. Year 1 of operations is in 2006, with continued operation of the ICM system (Alternative 1). Year 4 of operations is in 2009, with operation of the Alternative 5 source area SVE and groundwater extraction systems. For costing purposes, it is assumed that Alternative 7 will be pilot tested in 2008, designed and installed in 2009, and will operate for 26 years (2010 through 2035).

The capital costs would include those of the baseline alternative (Alternative 1) plus the additional cost of designing and constructing the source area steam sparging, vapor extraction, groundwater extraction systems. Capital costs for Alternative 1 are incurred

through 2003. Capital costs for Alternative 7 in addition to Alternative 1 (baseline) include the following:

- Installing the SVE and vapor treatment systems per Alternative 5, including upgrades to the SVE system well and piping network for high temperatures, in 2008;
- Installing expanded source area groundwater extraction system, including upgrades to the groundwater extraction system well and piping network for high temperatures, in 2008;
- Conducting a steam sparge pilot test in 2008;
- Designing and reporting for source area steam sparging in 2008;
- Installing source area steam sparging wells, conveyance piping, and controls in 2009;
- Purchasing and installing steam boiler in 2009;
- Installing thermocouple temperature monitoring probes in 2009; and
- Upgrading vapor and groundwater treatment systems to accommodate higher flows, mass loading, and operating conditions in 2009.

Future and recurring costs in addition to Alternative 5 would include the following:

- Additional sampling and operation and maintenance costs associated with steam sparging;
- Increased utility costs associated with steam sparging;
- Performance monitoring of the steam sparging system;
- Temperature monitoring of the steam sparging system; and
- Maintenance of the asphalt surface in the source area.

Total capital costs for this Alternative 7 would be approximately \$2,560,000, in addition to the \$3,000,000 for Alternative 1 and \$850,000 for Alternative 5, for a total capital cost of \$6,410,000 in 2004 dollars. The NPV of recurring and future costs over the 30-year project life would be approximately \$7,090,000. The total estimated NPV for this alternative is \$13,500,000.

Refer to Table 7-5 for a breakdown of capital and projected recurring and future costs for Alternative 7.

7.5 Alternative 10: Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area *In Situ* Oxidation, and Natural Attenuation

Alternative 10 expands on Alternative 5 by adding *in situ* oxidation as the primary mechanism to remove contaminant mass from below the water table in the source area. An expanded source area groundwater extraction system would be used to assist distribution of oxidant (permanganate) and to control migration of the groundwater plume during *in situ* oxidation. Alternative 10 includes 30 years of operations and monitoring. Alternative 10 is anticipated to be initiated after approximately two additional years of groundwater and SVE ICM operations. Figure 7-5 includes a conceptual layout of the source area *in situ* oxidation injection wells, SVE wells, and expanded source area groundwater extraction wells. Refer to Appendix B for a complete description of the source area.

7.5.1 Alternative 10 Description

Source Area SVE

The expanded SVE system will be consistent with Alternative 5. Refer to Section 7.2.1 for a description of the expanded SVE system. The main purpose of the SVE system will be to remove contaminant mass and to prevent migration of VOC vapors off site. The SVE system would operate continuously during permanganate injection.

Expanded Source Area Groundwater Extraction

The expanded source area groundwater extraction system will be similar to the Alternative 6 groundwater extraction system in Section 7.3.1. Oxidant injection may increase dissolved VOC concentrations by liberating residual NAPL in saturated soil. Therefore, the purpose of the groundwater extraction system will be to remove contaminant mass, assist in the distribution of oxidants in the subsurface, and control groundwater gradients to minimize the migration of contaminants during oxidant injection.

The additional 5 groundwater extraction wells will require approximately 700 feet of additional groundwater conveyance piping. The source area extraction system is expected to operate at up to 60 gpm (total) to match the anticipated injection rate of oxidant solution (up to 45 gpm) and provide gradient control (15 gpm). The ICM groundwater wells are anticipated to operate between 15 and 24 gpm (total).

Additional water treatment capacity will be required to handle an expected increased suspended solid loading as a result of permanganate injection. Additional equipment may include a self-backflushing sandfilter and settling tanks. The ICM air stripper will likely need to be expanded or an additional air stripper added to provide sufficient VOC

treatment capacity. Water effluent from the air stripper would be split between the permanganate injection system and the sanitary sewer under a NPDES permit. It is expected that the permanganate injection system would require up to approximately 45 gpm of water.

Source Area *In Situ* Oxidation

Chemical oxidation uses a strong oxidizer to chemically transform target contaminants. If the process goes to completion, the end products are carbon dioxide and water. The objective of *in situ* oxidation is to destroy contaminants in the source area and reduce overall cleanup time. Under this alternative, an oxidant would be injected into the shallow water-bearing zone to oxidize contaminants *in situ*. The oxidizer could be injected either through temporary injection points or through permanent injection wells. The most probable oxidant is either potassium permanganate (KMnO₄) or sodium permanganate (NaMnO₄). These oxidants are assumed because of their stability in the subsurface, applicability to groundwater remediation, and successful application at similar sites. Other oxidants that could be considered during design and pilot testing include hydrogen peroxide, ozone, and Fenton's reagent.

In situ chemical oxidation is more aggressive than *in situ* air sparging or pump-and-treat because it treats zones of DNAPL that can be a continuing source of dissolved-phase contamination. At some sites, *in situ* chemical oxidation can reduce the overall remediation costs as compared to other remediation methods because the time of remediation can be significantly reduced by targeting treatment of a high-concentration source zone.

Effective oxidation depends on contact between the oxidant and the contaminant. Therefore, design typically focuses on methods of effective distribution of the oxidant. Poor contact caused by inadequate injection density, preferential flow paths, or poor mixing in the subsurface can lead to inadequate treatment.

Injection System. Injection points would be located, designed, and installed to maximize distribution of the oxidant throughout the contaminated area. The injection points could be nested at different depths to enhance vertical distribution of oxidant. For costing purposes, it was assumed that the permanganate injection system will consist of 17 injection wells installed on approximately 40-foot centers in areas of known or suspected releases in the source area. The actual zone of influence of an injection well would be determined during a pilot test. The number and location of injection points could allow injection of the oxidant to alternate between sets of injection points to minimize adverse impacts of short circuiting and preferential flow. The injection wells would be connected by a network of piping and headers to inject permanganate solution below the water table.

Oxidant Demand. There are several important factors in determining the amount of oxidant required to treat a given volume of contaminated soil and groundwater, including the mass and type of contaminants present, the oxidant demand of the soil and

groundwater (e.g., naturally occurring organics), and the ability to effectively distribute the oxidant. Using the types of VOCs present (e.g., chlorinated and non-chlorinated VOCs) and the estimated contaminant mass in the source area (residual NAPL estimated at 354,000 lbs), it would take approximately 1,460,000 pounds of permanganate to completely destroy the contaminants assuming “perfect” reaction kinetics were achieved (i.e., only needed the theoretical stoichiometric amount of oxidant). Based on experience at other sites with this technology, the amount of oxidant required to overcome the natural oxidant demand can range from a low 1.5 or 2 times the stoichiometric quantity in clean sands with low organic content to a factor of 4 or more in organic silts and peaty soils. Finally, an “efficiency factor” is used to account for less than perfect distribution of oxidant.

Based on these general assumptions, it is estimated that approximately 8.7 million pounds of potassium permanganate will be required to oxidize the contaminants and overcome matrix oxidation demands. The oxidant would be delivered to the site in bulk semi-truck or train loads of approximately 30,000 to 40,000 pounds per week. Between 5,000 and 6,000 pounds of potassium permanganate are expected to be used daily. The oxidant would be metered into a tank and mixed with approximately 27,000 gallons of water each day (from the groundwater pump and treat system). The permanganate solution would need to be injected at a rate of 45 gpm for 10 hours each day, 6 days per week over a 5 year period.

Pilot Testing. Pilot testing would be conducted in 2008. Pilot testing includes bench and field testing. Bench tests of alternative oxidants to determine empirical oxidant requirements and destruction kinetics are recommended. A field pilot test is also recommended to assess attainable injection rates and mobility of oxidants. Once hydraulic injection rates and zone of influence are determined, hydraulic modeling could be conducted to determine the optimum number and placement of injection wells. Groundwater flow modeling would be performed to demonstrate hydraulic control, flushing times, or flow regime.

Natural Attenuation. Alternative 10 will include natural attenuation processes as summarized in Section 2.6.3, and described in detail in Appendix C. However, the addition of a strong oxidant in the source area is expected to sterilize much of the subsurface and eliminate ongoing biological activity in the area treated. Once permanganate injection has ceased, natural attenuation processes are expected to slowly re-establish themselves at some rate due to residual contaminant mass in the subsurface that was not removed by permanganate injection. However, it is not known at this time if the rate of VOC removal via MNA will be a significant factor in contaminant mass removal following *in situ* oxidation.

Implementation

Alternative 10 source would be implemented in stages. In 2008, after approximately two additional years of groundwater ICM operation, the Alternative 5 groundwater and SVE systems would be installed. The *in situ* oxidation pilot testing would be conducted

concurrent or following installation of the Alternative 5 systems in 2008. The final *in situ* oxidation system would be installed in 2009, and operations would begin in 2010.

As discussed in previous alternatives, the exact locations of the wells will be based on engineering design as well as field data compiled during drilling activities. Permanganate injection system installation will require two major construction events (in 2008 and 2009), which will require significant coordination with the facility, as discussed in previous alternatives.

Another factor unique to chemical oxidation that would effect implementation of this technology is the danger associated with handling large quantities of strong oxidants in proximity to the large volumes of organic solvents stored and handled at the Univar facility. Accidental mixing of these two types of chemicals would cause a significantly exothermic reaction to occur, resulting in the possibility of fire or an explosion. Great care would have to be taken to prevent these from occurring.

Institutional Controls. Institutional controls would be placed on the site property title as discussed in Section 7.1.1.

Engineering Controls. Engineering controls for Alternative 10 include those described for Alternative 1, as well as measures designed to prevent contact of oxidant with solvents or other oxidizable and flammable materials handled at the Univar site.

7.5.2 Effectiveness and Performance

Timeframe

A 30-year operating life was used for cost comparison purposes. The first year of operation (2006) would be operating the ICM groundwater and SVE systems. The fourth year of operation (2009) would be operating the Alternative 5 source area groundwater and SVE systems. The pilot study would be performed in 2008 and *in situ* oxidation system design would be performed in 2009. The remaining 26 years of project life would be operating the Alternative 10 remediation system.

In situ oxidation would operate for five years, until significant contaminant mass removal was attained. After five years, it is expected that the cost for oxidant injection relative to contaminant mass removal would have increased significantly. However, depending on matrix demands and oxidation efficiency, additional *in situ* oxidation may be required. The SVE system would operate full scale when the oxidation system was in operation (five years). A smaller-scale SVE system (i.e., fewer operating SVE wells and lower vapor concentrations) would then be operated to remove residual VOC mass in the vadose zone for 6 additional years until year 15 of operation. Source area groundwater wells are expected to operate for 30 years. After *in situ* oxidation is complete, a reduced number of source area wells would be required for contaminant mass removal and gradient control. For cost comparison, extraction well EXW-4A would be shut off after 3 years, and wells EXW-2 and EXW-3 would be shut off after 15 years.

Contaminant Mass Reduction

The estimated mass reduction associated with Alternative 10 is discussed below.

Remediation System Operations. The *in situ* oxidation system would operate concurrent with the expanded SVE and groundwater systems to remove and treat contaminants from below the water table. Because of the aggressive nature of permanganate injection, source area VOC concentrations are expected to decrease significantly in 5 years of operation. The geometry of the contaminant plume and the concentric layout of the groundwater extraction system would probably result in significant contraction of the plume. The ICM wells are located on the edges of the contaminant plume, where contaminants are primarily by-products of anaerobic biodegradation of the source area contaminants. The source area groundwater extraction wells should cut off the source plume from the ICM wells. Over time, downgradient VOC concentrations would decrease and the downgradient ICM wells could probably be shut off.

By the end of *in situ* oxidation operations, it is expected that 85 to 90 percent of the total contaminant mass will be removed. An additional 5 to 10 percent of the contaminant mass is expected to be removed by operating the smaller scale SVE system (6 years), and groundwater extraction system (21 years). Over a 30-year operating period, Alternative 10 operations are expected to remove between 420,000 and 450,000 pounds of mass.

Natural Attenuation. *In situ* oxidation is expected, for practical purposes, to eliminate natural attenuation for the duration of this alternative. For the purposes of this contaminant mass removal estimate, it is assumed that natural attenuation will not contribute to VOC mass removal in Alternative 10.

Alternative 10 Total Contaminant Mass Reduction Estimate. Based on remediation system operation, the total contaminant mass reduction estimate for Alternative 10 is expected to be between 420,000 and 450,000 pounds over 30 years. Approximately 160,000 pounds will be removed during the first five years. This is approximately 90 to 95 percent of the total estimated contaminant mass (468,000 pounds) in the subsurface.

7.5.3 Cost

A 30-year operating life was used to calculate cost. All costs are calculated in NPV 2004 dollars using an assumed 7 percent discount rate. Year 1 of operations is in 2006, with continued operation of the ICM system (Alternative 1). Year 4 of operations is in 2009, with operation of the Alternative 5 source area SVE and groundwater extraction systems. For costing purposes, it is assumed that Alternative 10 will be pilot tested in 2008, designed and installed in 2009, and will operate for 26 years (2010 through 2035).

The capital costs would include those of the baseline alternative (Alternative 1) plus the additional cost of designing and constructing the source area *in situ* oxidation, vapor extraction, and groundwater extraction systems. Capital costs for Alternative 10 include

the construction and operation of the ICM incurred through 2003. Capital costs for Alternative 10 in addition to Alternative 1 (baseline) include the following:

- Conducting bench treatability tests of oxidants site specific conditions in 2008;
- Conducting injection well tracer test and field treatability pilot test in 2008;
- Installing the expanded source area SVE system and groundwater extraction system in 2008;
- Upgrading the vapor treatment system per Alternative 5 in 2008;
- Designing and reporting for *in situ* oxidation in 2009;
- Installing *in situ* oxidation delivery wells, conveyance piping, controls in 2009;
- Purchasing and installing chemical handling equipment to control and deliver the oxidant in 2009; and
- Installing additional groundwater pump and treat equipment 2009.

Future and recurring costs in addition to Alternative 10 would include the following:

- Additional sampling and O&M costs associated with *in situ* oxidation;
- *In situ* oxidation chemical costs;
- Performance monitoring of the *in situ* oxidation system; and
- Maintenance of the asphalt surface in the source area.

Total capital costs for this Alternative 10 would be approximately \$1,210,000, in addition to the \$3,000,000 for Alternative 1 and \$850,000 for Alternative 5, for a total capital cost of \$5,060,000 in 2004 dollars. The NPV of recurring and future costs over the 30-year project life would be approximately \$14,770,000; the NPV cost for the potassium permanganate alone is over \$7,000,000. The total estimated NPV for this alternative is \$19,830,000.

Refer to Table 7-6 for a breakdown of capital and projected recurring and future costs for Alternative 10.

7.6 Alternative 11: Groundwater ICM, Expanded SVE, Source Area Groundwater Extraction, Source Area Enhanced *In situ* Biodegradation, and Natural Attenuation

Alternative 11 includes all of the elements of Alternative 5 (ICM, expanded SVE, source area groundwater extraction, and natural attenuation) and adds source area enhanced

in situ biodegradation. Alternative 11 includes 30 years of operation and natural attenuation. The expanded SVE and source area groundwater extraction systems will likely be installed following two additional years of Alternative 1 operation. Enhanced *in situ* biodegradation will be implemented in areas, and at the time, deemed necessary by the routine evaluation of natural attenuation data at the site. Refer to Figure 7-2 for a layout of the expanded SVE and source area groundwater extraction systems. Refer to Appendix B for a description of the source area.

7.6.1 Alternative 11 Description

Source Area SVE

The expanded SVE system will be installed and operated consistent with Alternative 5 (see Section 7.2.1). The main purpose of the SVE system will be to remove contaminant mass and to prevent migration of VOC vapors offsite. Enhanced *in situ* biodegradation is not expected to add contaminant mass loading to the SVE system, so additional vapor treatment capacity is not included.

Source Area Groundwater Extraction

The groundwater extraction and treatment system will be consistent with Alternative 5 (see Section 7.2.1). The primary purpose of the source-area groundwater pump-and-treat system will be to remove mass from the source area and to control groundwater gradients to minimize the migration of contaminants from the source area toward the perimeter ICM wells. Over the long term, operation of source area wells should result in decreasing concentrations in the ICM wells, allowing the perimeter ICM wells to be shut off.

When enhanced *in situ* biodegradation is implemented, groundwater extraction could be an important component of the delivery and distribution system for the supplements (e.g., nutrients, electron donors) used to augment the biodegradation processes. The use of the groundwater extraction wells for this purpose is not, however, expected to add contaminant mass loading to the groundwater extraction system, so additional water treatment capacity is not included.

Source Area Enhanced *In situ* Biodegradation

Source area *in situ* biodegradation is expected to consist primarily of reductive dechlorination. There may also be removal through oxidative processes, however the site is overwhelmingly anaerobic due to the significant amount of organic carbon present and high biological activity. These conditions foster biodegradation through reductive dechlorination.

Natural attenuation will be monitored and *in situ* biodegradation will be enhanced as necessary. The site geochemistry and patterns of degradation indicate that reductive dechlorination is the major mechanism of degradation. Chemical additives are expected to optimize the rate of biodegradation to continue to remove significant contaminant mass in the source area after existing electron donors are depleted via natural processes. The key factor driving this reaction is the presence of highly reducing conditions resulting in hydrogen production. If it is determined that the existing electron donors (aromatic compounds and alcohols) become limiting, then pilot studies evaluating augmentation with simple organic compounds (e.g., lactate) will be conducted. These compounds are easily fermentable substrates resulting in generation of hydrogen to support dechlorination. It is not known at this time exactly where in the source area, or at what point in time, these enhancements will begin. Nor is it known what enhancements will be necessary.

For purposes of cost estimating, implementing enhanced *in situ* biodegradation would include a pilot study of additives (e.g., lactate), installation of five to 10 additive injection points, and installation of approximately 2000 feet of additive conveyance piping. Additive mixing and metering equipment consisting of 1,000 gallon batch tank, mixer, feed pump, piping, valves, meters, and controllers would be installed in the treatment building.

Pilot Testing. Pilot testing would be conducted when natural attenuation monitoring data indicates that biodegradation enhancements could be advantageous. For purposes of the CMS, it will be assumed that implementation of enhanced *in situ* biodegradation would take place after 6 years of monitoring and evaluating the existing natural attenuation processes (i.e., year 7). As noted above, pilot testing will be implemented sooner if indicated by monitoring data. Pilot testing includes bench and field testing. Bench tests of alternative additives to determine empirical additive requirements and degradation kinetics are recommended. A field pilot test is also recommended to assess attainable injection rates and mobility of additives. Once hydraulic injection rates and zone of influence are determined, hydraulic modeling could be conducted to determine the optimum number and placement of injection wells. Groundwater flow modeling would be performed to demonstrate hydraulic control, flushing times, or flow regime.

The pilot study is expected to occur over a one-year period.

Additive Injection. Following the pilot testing, a full-scale additive mixing, delivery, and injection system will be designed and implemented. Depending on the outcome of the pilot testing and site conditions at the time of implementation, additives would be added either continuously or periodically to the target areas as long as needed to sustain a high level of biodegradation.

Natural Attenuation

Alternative 11 will include an expanded evaluation and monitoring of natural attenuation processes; this evaluation and monitoring will be a key component of Alternative 11 as it

will provide information regarding the timing and location of additive injection. The evaluation and monitoring is not a formal implementation of an MNA approach, but the approach will be consistent with the EPA OSWER policy document titled "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites" (OSWER Directive 9200.4-17P).

The approach will include ongoing monitoring and evaluation of site hydrogeology, geochemistry, and contaminant concentrations to ensure the attenuation processes in general, and the biodegradation component in particular, are occurring at adequate rates and also determine when it would be appropriate to implement the enhanced *in situ* biodegradation component of this alternative.

Implementation

The expanded SVE and source groundwater extraction system (Alternative 5) will be installed after approximately two years of groundwater ICM operation as discussed in Section 7.2.1. Source area *in situ* enhanced biodegradation is expected to be implemented following 3 years of Alternative 5 operation.

Institutional Controls. Institutional controls would be placed on the site property title as discussed in Section 7.1.1.

Engineering Controls. Engineering controls for Alternative 5 would be as described in Section 7.1.1.

7.6.2 Effectiveness and Performance

Timeframe

A 30-year operating life was used for cost comparison purposes. The first three years of operation would be continued operation the ICM groundwater and SVE systems. The next 5 years would be operation of the expanded source area groundwater and SVE extraction systems (Alternative 5). The remaining 22 years of project life would be operating the Alternative 11 remediation system.

The expanded source area SVE system is assumed to operate the entire 30 years. However it is estimated that groundwater extraction would reduce the source of VOC vapors to the vadose zone, so SVE system operations could be reduced by half after 15 years of operation. A smaller scale SVE system (i.e., fewer operating SVE wells and lower vapor concentrations) would then be operated to control the residual VOC mass in the vadose zone. Source area groundwater wells are expected to operate for 30 years, EXW-4A would be shut off after 2 years, and EXW-2 and -3 would be shut off after 15 years.

As described above, source area enhanced *in situ* biodegradation is expected to be implemented following 5 years of Alternative 5 operation. It is likely that enhanced biodegradation will occur at some level for the remainder of the operating period.

Mass Reduction

The anticipated mass reduction expected to occur due to implementing Alternative 11 remediation systems and due to monitored natural attenuation are described below.

Remediation System Operations. The SVE and groundwater systems are expected to remove significant mass in the source area. The SVE system is expected to draw high vapor concentrations in the initial years of operation, and then concentrations should steadily drop off as the mass of contamination in the vadose zone decreases. VOC concentrations in groundwater would also gradually decrease over time. The geometry of the contaminant plume and the concentric layout of the groundwater extraction system would probably result in a gradual contraction of the plume. The ICM wells are located on the edges of the contaminant plume where contaminants are primarily by-products of anaerobic biodegradation of the source area contaminants. The source area groundwater extraction wells should cut-off the source plume from the ICM wells. Over time, downgradient VOC concentrations would decrease and the downgradient ICM wells could probably be shut off.

Chemical additives are expected to optimize the rate of biodegradation to continue to remove contaminant mass in the source area after the existing source of electron donors is consumed. The groundwater extraction system is expected to continue to remove significant mass in the source area and will continue to contain the source area by controlling groundwater gradients.

Following removal of mass in the source area vadose zone, VOC recovery in the vadose zone will be limited by the rate of molecular diffusion from the groundwater. At this point, the primary intent of the SVE system will be to protect indoor air quality at the facility from inhalation of VOC vapors.

Over the life of the project, the SVE system is expected to remove approximately 100,000 to 125,000 pounds of mass with most of the mass removal in the first 10 years. The groundwater system is also expected to remove approximately 100,000 to 150,000 pounds of mass. Enhanced biodegradation is expected to remove 65,000 pounds of mass in the source area. For the entire 30 year operating period, Alternative 11 system operations is expected to remove approximately 281,000 to 381,000 pounds. Approximately 110,000 pounds will be removed during the first five years. This is approximately 60 to 81 percent of the total estimated mass (468,000 pounds) in the subsurface.

7.6.3 Cost

A 30-year operating life was used. All costs are calculated NPV 2004 dollars using an assumed 7 percent discount rate. Year 1 of operations is in 2006 with continued operation of the ICM system (Alternative 1). For costing purposes, it is assumed that Alternative 5 will be designed and installed in 2008, started up in 2009, and will operate for 27 years (2009 through 2035). Alternative 11 biodegradation enhancement system will be designed in 2012 (including pilot test), installed in 2013, and will operate for 22 years (2013 through 2035).

The capital costs would include those of the baseline alternative (Alternative 1) plus the additional cost of designing and constructing the source area groundwater extraction system. Capital costs for Alternative 11 include the construction and operation of the ICM incurred through 2003. Capital costs for Alternative 5 are incurred in 2008, and capital costs for Alternative 11 biodegradation enhancements will be incurred in 2012 and 2013, however capital costs are tabulated in NPV 2004 dollars. Capital costs in addition to Alternative 5 (baseline) include the following:

- Conducting bench treatability tests of additives and site specific conditions in 2012;
- Conducting injection-well tracer test and field treatability pilot test in 2012;
- Designing and reporting for enhanced *in situ* biodegradation in 2012;
- Installing source area delivery wells, conveyance piping, controls in 2013; and
- Purchasing and installing chemical handling equipment to control and deliver the chemicals in 2013.

Future and recurring costs in addition to Alternative 5 would include the following:

- Additional sampling and O&M costs associated with enhanced biodegradation;
- Chemical additive costs; and
- Maintenance of the asphalt surface in the source area.

Total capital costs for this Alternative 11 would be approximately \$410,000 in addition to the \$3,000,000 for Alternative 1 and \$850,000 for Alternative 5, for a total capital cost of \$4,260,000 in 2004 dollars. The NPV of recurring and future costs over the 30-year project life would be approximately \$5,420,000. The total estimated NPV for this alternative is \$9,680,000. Refer to Table 7-7 for a breakdown of capital and projected recurring and future costs for Alternative 11.

8 DETAILED EVALUATION OF ALTERNATIVES

This section of the CMS provides a detailed evaluation of the CAAs developed in Section 7. The criteria used for analysis are presented in Section 8.1 while the individual CAAs are evaluated against these criteria in Section 8.2. Finally, a comparative evaluation of the retained remedial alternatives for each evaluation criteria is presented in Section 8.3.

8.1 Evaluation Criteria

The section summarizes the criteria for remedial alternative evaluation listed in the RCRA Corrective Action Plan (OSWER Directive 9902.3-2A, EPA, 1994). The RCRA Corrective Action Plan establishes a two-tiered approach for evaluation of CAAs, with two corresponding sets of evaluation criteria.

8.1.1 RCRA Performance Standards

In the first tier of the evaluation, the CAAs are evaluated for their ability to meet the following RCRA remedy performance standards (EPA, 1994):

- Protect human health and the environment;
- Attain media cleanup objectives (for current and reasonably anticipated land and resource uses); and
- Remediate the sources of releases to reduce or eliminate further release that might pose threats.

For the Univar site, these three general remedy performance standards are addressed by the CAOs developed in Section 4.4. The CAAs were evaluated against these remedy performance standards and the CAOs in Section 6; this evaluation is summarized below.

8.1.2 Balancing Criteria

For those CAAs that, to varying degrees, meet the remedy performance standards, the second stage of the process uses the following balancing criteria:

- Long-term Reliability and Effectiveness;

- Reduction of Toxicity, Mobility, or Volume;
- Short-term Effectiveness;
- Implementability; and
- Cost.

These five criteria are used in the remainder of this section to provide a detailed and comparative evaluation of the CAAs. Finally, the RCRA Correction Action Plan (EPA 1994) establishes community and state acceptance as two additional balancing criteria. These final two criteria will be briefly evaluated in Section 9 for the CAA recommended for implementation, and in detail during the public review and comment process outlined in Section 10.

Each of the five primary balancing criteria are defined below.

Long-Term Reliability and Effectiveness. Long-term reliability and effectiveness is the ability of a CAA to provide adequate protection of human health and the environment over a long period of time. Both the degree to which protection is provided, and the long-term reliability of this protection, are important considerations. Source control technologies that involve treatment of contamination, or that otherwise do not rely on containment structures or systems to ensure against future releases, are preferred to more temporary, or less reliable controls. The evaluation of long-term effectiveness also considers potential future land uses at the site.

Reduction of Toxicity, Mobility, or Volume. This criteria is a specific means of achieving the broader objective of long-term reliability. It is used to evaluate the degree to which remedies implement treatment technologies that are capable of eliminating or substantially reducing the overall potential for wastes and/or contaminated media at the site to cause future environmental releases or other risks to human health and the environment.

For this CMS, the primary means of evaluating this criterion will be the mass removal achieved by an alternative. There are two key aspects to estimating the mass removal for an alternative: (1) the quantity and distribution of contaminants at the site and (2) the effectiveness of an alternative in removing or destroying the contaminants. As described in Appendix B (Source Area Contaminant Mass Estimation), there is significant uncertainty associated with the total estimate of mass at the site, including uncertainties with the vertical and horizontal distribution of contaminants and the potential presence of NAPLs.

The effectiveness of each alternative in removing contaminant mass is estimated in Section 7 and summarized in Table 8-1. Aside from the total mass present at the site, the major uncertainty or assumption with these estimates is the ability to effectively implement the alternative. The mass estimates presented in Section 7 assume that the technologies included in the alternative (i.e., expanded source area SVE) can be

implemented in a manner that will effectively remove or treat the contaminants. To the extent that implementability issues cannot be adequately overcome (e.g., extraction wells not optimally located due to site operations), or site conditions vary significantly from those assumed during system design (e.g., previously unidentified soil heterogeneities, presence of NAPL), actual mass removal rates could be lower.

The net result of these uncertainties is that the mass removal estimates need to be considered approximate and used as a tool to compare one alternative against others. The estimate of the absolute value of mass removed (and therefore the percentage of the total mass removed) should be carefully considered taking into account the implementability issues discussed for each alternative.

Short-term Effectiveness. Short-term effectiveness addresses two primary factors: (1) the risk reduction achieved immediately or shortly after implementation of the remedy (i.e., time until protection is achieved) and (2) the risks posed to the community, site workers, or the environment during remedy implementation.

The second factor (i.e., implementation risk) is particularly relevant when remedial activities will be conducted in densely populated areas, or where waste characteristics are such that risks to workers, community, or the environment are high and special protective measures are needed. Possible factors can include fire, explosion, exposure to hazardous substances, and potential threats associated with the treatment, excavation, transportation, and redisposal or containment of waste material. A specific implementation risk that will be considered is the potential risks to nearby workers associated with air emissions related to corrective actions (e.g., VOC emissions from groundwater and SVE treatment systems). This risk will be considered qualitatively in the evaluation below. A quantitative estimation of the risk associated with air emissions will, however, be performed in Section 9 for the preferred corrective action alternative.

Implementability. Implementability refers to the practical, technical, and legal limitations, constraints, or unknowns associated with permitting, constructing, operating, monitoring, and maintaining the remedy. Specific considerations can include:

- Administrative activities needed to implement the corrective measure (e.g., permits, right-of-ways, off-site approvals) and the length of time these activities will take;
- The constructability and complexity of the corrective action and the time required for implementation;
- Availability of services, materials, or expertise; and
- Ease of undertaking additional remedial action, if necessary.

Cost. The cost of the CAA is an important consideration, especially in the situation where several different CAAs will offer equivalent or similar results (i.e., achieve the

CAOs), but vary widely in cost. The reasonableness of cost is a comparative analysis that considers the following specific factors:

- The net present value (NPV) or present worth (PW) of total CAA cost (capital costs, recurring costs, and future costs);
- Degree to which the costs of the remedial action are proportionate to the benefits to human health and the environment created through risk reduction or risk management (cost-effectiveness);
- Degree to which the costs are proportionate to the benefits created through restoration or protection of existing and reasonably likely future beneficial uses of land and water; and
- Degree of sensitivity and uncertainty of the costs.

8.2 Detailed Evaluation of Retained Remedial Alternatives

In this section, the CAAs are compared individually against the evaluation criteria defined in Section 8.1.2. As noted above, each of the retained alternatives has already been evaluated against the RCRA performance standards conducted in Section 6 and, in part, were retained *because* they met these performance standards. These performance standards are reflected on a site-specific basis by the CAOs defined in Section 4.4.

The extent to which each of the alternatives meet the CAOs is addressed either directly or indirectly by the five balancing criteria. For example, the CAOs related to protecting on and off-site receptors from exposure to site-related contaminants is addressed by the “long-term reliability and effectiveness” criteria and the CAO related to source control is addressed by the “reduction in toxicity, mobility, and volume” criteria. A summary of how the alternatives meet the RCRA performance standards provided in Section 8.3.1.

8.2.1 Alternative 1: SVE ICM, Groundwater ICM, and Natural Attenuation

This alternative has been retained to serve as a baseline for comparisons with the other retained alternatives. Each of the evaluation criteria is presented below with a discussion of how well this alternative meets the criterion.

Long-Term Reliability and Effectiveness. The groundwater ICM effectively controls the migration of contaminants from the site by capturing impacted groundwater from the perimeter of the plume, treating the extracted groundwater onsite, and discharging treated groundwater to the storm sewer system. The ICM will reliably provide long-term protection for potential off-site receptors.

With respect to potential on-site receptors (i.e., indoor office workers), Alternative 1 provides moderate protection of human health in the long-term. The groundwater ICM should reduce the plume at the north end of the site such that VOC concentrations

adjacent to and beneath the office building will significantly decrease over a relatively short period of time (e.g., 2 to 4 years). The existing SVE system provides control of vapors in the loading dock area.

The alternative is expected to operate for an extended period of time (30 years or more). Over this extended period, the level of effectiveness of the ICM components would tend to degrade without ongoing operations and maintenance activities. Natural attenuation processes will continue to degrade VOCs in soil and groundwater over time, although the rates and effectiveness may change as subsurface conditions (e.g., geochemistry and specific contaminant concentrations) change.

Reduction of Toxicity, Mobility, or Volume. Alternative 1 significantly reduces the mobility of contaminants by controlling off-site migration at the north and south ends of the site. This alternative does not, however, reduce the mobility of contaminants from the source area and only achieves moderate reduction of contaminant volume (i.e., mass) or toxicity in the source area. Ongoing natural attenuation is estimated to be destroying approximately 2,700 lbs/yr of VOCs (see Appendix C), and the existing SVE system is removing approximately 300 to 400 lbs/yr. The groundwater ICM has initial mass removal rates of approximately 500 to 700 lbs/yr; this rate will decrease to 300 to 600 lbs/yr over time after extraction well EXW-4a is shut off and VOC concentrations in the other wells decline. Over 30 years, Alternative 1 will remove an estimated 102,000 to 113,000 lbs of VOCs, or 22 to 24 percent of the total estimated contaminant mass (see Appendix B).

As noted above, the estimated mass removal rates are based on a number of assumptions regarding contaminant mass present, effectiveness of remedial technologies, and implementability. These estimates should be used for comparative purposes only.

Short-Term Effectiveness. Alternative 1 provides a low to moderate level of risk reduction in the short-term. Potential off-site receptors (i.e., office workers, trench workers) would be protected as off-site VOC concentrations decline as the groundwater ICM continues to operate. As noted above, potential risks to on-site office workers were reduced shortly after ICM startup and following procedures established in institutional controls would protect on-site trench workers.

The implementation risks associated with Alternative 1 are very low as it includes a limited amount of intrusive work (e.g., trenching, well installation) and the VOCs extracted from groundwater and soil vapors will be treated and collected for off-site disposal. VOC emissions from the treatment system represent a potential risk to nearby workers. The treatment system is designed to minimize this potential risk. If this alternative is recommended for implementation, these potential risks will be quantified in Section 9 to ensure that the treatment system is adequate to protect nearby workers.

Implementability. This alternative would be relatively easy to implement. The SVE and groundwater ICM systems are currently in place and operating.

Experience, equipment, and services for both groundwater extraction and SVE, and vapor and water treatment of the VOCs are readily available. The equipment required for implementation and treatment of contaminated media is reliable and the operation and maintenance is relatively routine. Treated groundwater will be discharged to the storm sewer adjacent to the treatment building under the existing NPDES permit already in place for the facility.

Extensive natural attenuation has been documented at the site (Appendix C). Implementing the natural attenuation portion of Alternative 1 only involves groundwater monitoring, data analysis, and reporting.

Cost. The total estimated NPV cost for implementation and 30 years of operation of Alternative 1 is approximately \$6,980,000. This includes \$3,000,000 in capital costs and \$3,850,000 in O&M costs (see Table 7-1).

8.2.2 Alternative 5: Groundwater ICM, Expanded SVE, Source Area Groundwater Extraction, and Natural Attenuation

Each of the evaluation criteria is presented below with a discussion of how well this alternative meets the criterion.

Long-Term Reliability and Effectiveness. The groundwater ICM component of Alternative 5 will effectively control the migration of contaminants from the site by capturing impacted groundwater from the perimeter of the plume, treating the extracted groundwater onsite, and discharging it to the storm sewer system. The groundwater ICM will reliably provide long-term protection for potential off-site receptors.

With respect to potential on-site receptors (i.e., indoor office workers), Alternative 5 provides a high level of protection in the long-term. The groundwater ICM is reducing the plume at the north end of the site such that VOC concentrations adjacent to and beneath the office building will significantly decrease over a relatively short period of time (e.g., 2 to 4 years). Source area mass removal (groundwater extraction and expanded SVE) will further reduce the size of the plume and provide a higher level of long-term protection to indoor office workers. As the source is reduced and removed, the risk associated with potential future releases of the contaminants at the site will decrease.

Alternative 5 is expected to operate for an extended period of time (30 years or more). Over this extended period, the level of effectiveness of the groundwater extraction and SVE components would tend to degrade without ongoing operations and maintenance activities. Continued operation of the groundwater extraction system at both the source area and the north and south perimeters will allow the capture of the plume. The size of the plume will be reduced significantly, allowing some or all of the ICM wells to be removed from operation. Natural attenuation processes will continue to degrade VOCs in soil and groundwater over time, although the rates and effectiveness may change as subsurface conditions (e.g., geochemistry and specific contaminant concentrations) change.

Reduction of Toxicity, Mobility, or Volume. Alternative 5 significantly reduces the mobility of contaminants by controlling off-site migration at the north and south ends of the site and by controlling migration of contaminated groundwater and soil vapors from the source area. This alternative also reduces contaminant volume (i.e., mass) in the source area. Ongoing natural attenuation is estimated to be destroying approximately 2,700 lbs/yr of VOCs (see Appendix C). The groundwater ICM component has initial mass removal rates of approximately 500 to 700 lbs/yr. Mass removal rates for the source area groundwater extraction and expanded SVE system are estimated to be 50,000 lbs/yr during the first year of operation and decreasing over time. During the first five years of operation (through 2010), Alternative 5 is expected to remove approximately 110,000 lbs of VOCs. Over 30 years, Alternative 5 is expected to remove an estimated 281,000 lbs to 381,000 of VOCs, or 60 to 81 percent of the total estimated contaminant mass (see Appendix B).

As noted above, the estimated mass removal rates are based on a number of assumptions regarding contaminant mass present, effectiveness of remedial technologies, and implementability. These estimates should be used for comparative purposes only.

Short-Term Effectiveness. Alternative 5 provides a moderate to high level of risk reduction in the short-term. Potential off-site receptors (i.e., office workers, trench workers) would be protected as off-site VOC concentrations continue to decline due to the ongoing operation of the groundwater ICM. In addition, potential risks to on-site office workers would be reduced by declining groundwater concentrations in the vicinity of the office building resulting from ICM operation. These potential risks to on-site indoor air quality would be effectively eliminated once the expanded SVE wells adjacent to the office building were operational. Following procedures established in institutional controls would protect on-site trench workers.

The implementation risks associated with Alternative 5 are relatively low. Installation of the source area groundwater extraction and expanded SVE systems will involve intrusive work in areas of high contamination, buried utilities and chemical transfer piping, and ongoing operations. Potential risks associated with this work in the source area can be mitigated through careful system design, development and implementation of health and safety procedures, and close coordination with Univar operations. VOC emissions from the treatment system represent a potential risk to nearby workers. The treatment system is designed to minimize this potential risk. If this alternative is recommended for implementation, these potential risks will be quantified in Section 9 to ensure that the treatment system is adequate to protect nearby workers.

There is the potential for the operation of the source area groundwater extraction system to cause a lowering of the water table which could in turn cause differential settlement or subsidence in the dredge fill sands beneath the loading dock, tank farm, and rail spur areas. Such settlement could damage structures or underground utilities. Given the relatively flat water table in the source area and the fairly permeable sand in the shallow aquifer, pumping rates (and the resulting draw down of the water table) are expected to be low. The potential risk of settlement can be mitigated through careful design of the extraction system and monitoring of water levels during system operation.

The VOCs extracted from groundwater and soil vapors will be treated and collected for off-site disposal.

Implementability. Implementing the various portions of Alternative 5 would range from relatively easy (ICM components) to moderately difficult (expanded source area SVE and groundwater systems).

Construction in the source area will be significantly limited by existing facility operations and facility structures on the loading dock and between the railroad spur and the solvent tank farm (see Figure 5-1). Constructing a remediation system in these areas will provide significant challenges with respect to protecting existing structures and installing wells and piping in locations optimal for remediation. In some cases, piping may be routed above ground over certain underground features, but this will have to be evaluated on a case by case basis during final design.

Experience, equipment, and services for the groundwater extraction, SVE, and vapor and water treatment systems are readily available. The equipment required for implementation and treatment of contaminated media is reliable and the operation and maintenance is relatively routine. Maintenance of the groundwater extraction and SVE systems located in the source area will be more difficult due to the ongoing facility operations in this area. Treated groundwater will be discharged to the storm sewer adjacent to the treatment building under the existing NPDES permit already in place for the facility.

Extensive natural attenuation has been documented at the site (Appendix C). Implementing the natural attenuation portion of Alternative 5 only involves groundwater monitoring, data analysis, and reporting.

Cost. The total estimated NPV cost for implementation and 30 years of operation of Alternative 5 is approximately \$8,840,000. This includes \$3,850,000 in capital costs and \$4,990,000 in O&M costs (see Table 7-1).

8.2.3 Alternative 6: Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area Air Sparging, and Natural Attenuation

Each of the evaluation criteria is presented below with a discussion of how well this alternative meets the criterion.

Long-Term Reliability and Effectiveness. The long-term reliability and effectiveness of Alternative 6 is very similar to that of Alternative 5 in that potential off-site and onsite receptors are effectively and reliably protected (see Section 8.2.2 for detailed discussion). The groundwater ICM component of Alternative 6 will effectively control off-site contaminant migration while the source treatment actions, which include air sparging and SVE, will provide a high level of protection for indoor office workers in the long-term.

Although air sparging is generally applicable to site contaminants, the introduction of oxygen into the subsurface will cause iron to oxidize and precipitate, potentially restricting air flow and reducing the efficiency of sparging over time. Also, the effects of sparging on the ongoing biodegradation are uncertain. For example, the extent to which the anaerobic reductive dechlorination will switch to aerobic cometabolism during sparging, and then convert back to anaerobic reductive dechlorination after sparging is completed is unknown. This uncertainty reduces the overall reliability of this alternative.

Alternative 6 is expected to operate for an extended period of time (30 years or more). Over this extended period, the level of effectiveness of the groundwater extraction and SVE components would tend to degrade without ongoing operations and maintenance activities.

Reduction of Toxicity, Mobility, or Volume. Alternative 6 significantly reduces the mobility of contaminants by controlling off-site migration at the north and south ends of the site and by controlling migration of contaminated groundwater and soil vapors from the source area. This alternative also reduces contaminant volume (i.e., mass) in the source area through a combination of air sparging, groundwater extraction, and SVE. Mass removal rates for the combined source area air sparging, groundwater extraction, and expanded SVE system are estimated to be 65,000 lbs/yr during the first year of operation and decreasing over time. Over the first five years of operation (i.e., through 2010), Alternative 6 is expected to remove an estimated 150,000 lbs of VOCs. Over 30 years, Alternative 6 is expected to remove an estimated 270,000 lbs to 360,000 of VOCs, or 58 to 77 percent of the total estimated contaminant mass (see Appendix B). The lower overall mass reduction when compared to Alternative 5 is attributed to the reduced rate of natural attenuation (i.e., biodegradation) due to the oxidation of the subsurface by air sparging.

As noted above, the estimated mass removal rates are based on a number of assumptions regarding contaminant mass present, effectiveness of remedial technologies, and implementability. These estimates should be used for comparative purposes only.

Short-Term Effectiveness. Alternative 6 provides a moderate to high level of risk reduction in the short-term. Potential off-site receptors (i.e., office workers, trench workers) would be protected as off-site VOC concentrations would continue to decline due to ongoing operation of the groundwater ICM. In addition, potential risks to on-site office workers would be reduced by declining groundwater concentrations in the vicinity of the office building resulting from ICM operation. These potential risks to on-site indoor air quality would be effectively eliminated once the expanded SVE wells adjacent to the office building were operational. Although there is the potential for air sparging to result in elevated soil vapor concentrations in the source area, careful operation of the SVE and sparging systems should prevent these vapors from impacting on-site receptors. Following procedures established in institutional controls would protect on-site trench workers.

The implementation risks associated with Alternative 6 are relatively low. The ICM component only includes a limited amount of intrusive work (e.g., trenching, well

installation). As with Alternative 5, installation of the source area remediation systems will involve intrusive work in areas of high contamination, buried utilities and chemical transfer piping, and ongoing operations. Potential risks associated with this work in the source area can be mitigated through careful system design, development and implementation of health and safety procedures, and close coordination with Univar operations. VOC emissions from the treatment system represent a potential risk to nearby workers. The treatment system is designed to minimize this potential risk. If this alternative is recommended for implementation, these potential risks will be quantified in Section 9 to ensure that the treatment system is adequate to protect nearby workers. Also as with Alternative 5, there is limited potential for settlement due to lowering of the water table once operation of the source area groundwater system begins. This potential risk can be mitigated through careful design of the extraction system and monitoring of water levels during system operation.

The VOCs extracted from groundwater and soil vapors will be treated and collected for off-site disposal.

Implementability. In general, the implementability of Alternative 6 is similar to that of Alternative 5 (see discussion above). The inclusion of the air sparging wells and piping in the source area will further complicate the installation, but these difficulties can likely be overcome through careful design, planning, and coordination with the facility during construction.

Experience, equipment, and services for the air sparging, groundwater extraction, SVE, and vapor and water treatment systems are readily available. The equipment required for implementation and treatment of contaminated media is reliable and the operation and maintenance is relatively routine. Maintenance of the air sparging, groundwater extraction, and SVE systems located in the source will be more difficult due to the ongoing facility operations in this area. Treated groundwater will be discharged to the storm sewer adjacent to the treatment building under the existing NPDES permit already in place for the facility.

Extensive natural attenuation has been documented at the site (Appendix C). The introduction of oxygen into the subsurface will significantly impact the nature and rate of natural attenuation. While the sparging system is in operation, biodegradation may switch from anaerobic reductive dechlorination to aerobic cometabolism. Once the sparging system is shut down, the subsurface will presumably revert back to an anaerobic state, although it is unknown how quickly (or at what rate) anaerobic degradation will return. As noted above, the uncertainty of how the ongoing biodegradation will respond to oxygenation and then the return to anaerobic conditions somewhat decreases the implementability of this alternative. Implementing the natural attenuation portion of Alternative 6 will require groundwater monitoring, data analysis, and reporting.

Cost. The total estimated NPV cost for implementation and 30 years of operation of Alternative 6 is approximately \$9,890,000. This includes \$4,620,000 in capital costs and \$5,270,000 in O&M costs (see Table 7-1).

8.2.4 Alternative 7: Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area Steam Sparging, and Natural Attenuation

Each of the evaluation criteria is presented below with a discussion of how well this alternative meets the criterion.

Long-Term Reliability and Effectiveness. The long-term reliability and effectiveness of this alternative is very similar to that of Alternatives 5 and 6. The protection of potential off-site receptors (e.g., off-site office workers, the Willamette River) is provided by the groundwater ICM while potential on-site receptors (office workers) is provided via the expanded SVE system and source area groundwater extraction. The introduction of steam sparging into the approach for source area treatment would significantly increase initial mass removal rates, including potential removal of NAPL. This increased mass removal rate would not, however, provide a greater level of protection to potential receptors; the potential exposures would already be mitigated by the other actions.

Alternative 7 is expected to operate for at least 30 years, although the steam sparging component is only expected to operate for 3 years. The reliability of the steam sparging system should be adequate, although it is a very maintenance intensive technology. Over the longer term, the level of effectiveness of the groundwater extraction and SVE components would tend to degrade without ongoing operations and maintenance activities. As with Alternative 6, the effects of sparging on the ongoing biodegradation are uncertain and this uncertainty reduces the overall reliability of this alternative.

Reduction of Toxicity, Mobility, or Volume. Alternative 7 significantly reduces the mobility of contaminants in the groundwater plume by controlling off-site migration at the north and south ends of the site and by controlling migration of contaminated groundwater and soil vapors from the source area.

Alternative 7 also significantly reduces contaminant volume (i.e., mass) in the source area through a combination of steam and air sparging, groundwater extraction, and SVE. Mass removal rates for the combined source area air sparging, groundwater extraction, and expanded SVE system are estimated to be 100,000 to 200,000 lbs/yr during the first year of steam sparging operation. Over the first five years of operation (i.e., through 2010), Alternative 7 would remove an estimated 240,000 lbs of VOCs. Over 30 years, Alternative 7 would remove an estimated 420,000 lbs to 450,000 of VOCs, or 90 to 95 percent of the total estimated contaminant mass (see Appendix B).

As noted above, the estimated mass removal rates are based on a number of assumptions regarding contaminant mass present, effectiveness of remedial technologies, and implementability. These estimates should be used for comparative purposes only.

Short-Term Effectiveness. Alternative 7 provides a moderate to high level of risk reduction in the short-term. Potential off-site receptors (i.e., office workers, trench workers) would be protected as off-site VOC concentrations continue to decline due to

ongoing operation of the groundwater ICM. In addition, potential risks to on-site office workers would be reduced by declining groundwater concentrations in the vicinity of the office building resulting from ICM operation. These potential risks to on-site indoor air quality would be effectively eliminated once the expanded SVE wells adjacent to the office building were operational. The steam sparging system will generate very concentrated soil vapors in the source area. Careful operation of the SVE and sparging systems should prevent these vapors from impacting on-site receptors, although the risk to receptors could be significant if the vapors were not adequately controlled. Following procedures established in institutional controls would protect on-site trench workers.

There are moderate implementation risks associated with Alternative 7. The ICM component only includes a limited amount of intrusive work (e.g., trenching, well installation). Even more so than Alternatives 5 and 6, installation of the source area remediation systems will involve intrusive work in areas of high contamination, buried utilities and chemical transfer piping, and ongoing operations. Potential risks associated with this work in the source area can be mitigated through careful system design, development and implementation of health and safety procedures, and close coordination with Univar operations. VOC emissions from the treatment system represent a potential risk to nearby workers. The treatment system would be designed to minimize this potential risk. If this alternative is recommended for implementation, these potential risks will be quantified in Section 9 to ensure that the treatment system would be adequate to protect nearby workers. During operation of the steam sparging system, it would be very important to avoid elevated temperatures that could damage or destroy subsurface utilities and/or product lines. Such damage could lead to dangerous conditions or to the release of additional contaminants. Finally, there is the potential for injury to onsite workers due to high temperature, above ground piping.

Also as with Alternatives 5 and 6, there is limited potential for settlement due to lowering of the water table once operation of the source area groundwater system begins. This potential risk can be mitigated through careful design of the extraction system and monitoring of water levels during system operation.

The VOCs extracted from groundwater and soil vapors will be treated and collected for off-site disposal.

Implementability. In general, the implementability of Alternative 7 is low to moderate. Implementing steam sparging will require two separate and significant construction phases, one for the pilot study and one for the full-scale system. The inclusion of the steam sparging wells and piping in the source area will significantly complicate the construction and the need to protect existing facility utilities and product lines would further limit the accessibility to optimal areas for remediation. If effective implementation of steam sparging required relocation or replacement of utilities or product lines, the implementability of Alternative 7 would be significantly reduced.

Experience, equipment, and services for the steam sparging, groundwater extraction, SVE, and vapor and water treatment systems are available. The equipment required for implementation and treatment of contaminated media is reliable and the operation and

maintenance is relatively routine. Maintenance of the steam sparging system will be much more difficult due to the complexity of the system and the need to prevent damage to ongoing facility operations in this area. Treated groundwater will be discharged to the storm sewer adjacent to the treatment building under the existing NPDES permit already in place for the facility.

Extensive natural attenuation has been documented at the site (Appendix C). The introduction of oxygen and the elevated temperatures resulting from steam sparging will significantly impact the nature and rate of natural attenuation.

Cost. The total estimated NPV cost for implementation and 30 years of operation of Alternative 7 is approximately \$13,500,000. This includes \$6,410,000 in capital costs and \$7,090,000 in O&M costs (see Table 7-1).

8.2.5 Alternative 10: Groundwater ICM, Expanded SVE, Expanded Source Area Groundwater Extraction, Source Area In Situ Oxidation, and Natural Attenuation

Each of the evaluation criteria is presented below with a discussion of how well this alternative meets the criterion.

Long-Term Reliability and Effectiveness. The long-term reliability and effectiveness of this alternative is similar to that of Alternatives 5, 6, and 7, although more uncertain due to the use of in situ oxidation. The use of in situ oxidation as the primary source area treatment technology may result in significant initial mass removal rates, including potential removal of NAPL. As described above for Alternative 7, however, this increased mass removal rate would not provide a greater level of protection to potential receptors.

Alternative 10 is expected to operate for at least 30 years, although the in situ oxidation component is expected to operate for approximately 5 years. As noted above, the reliability and effectiveness of the in situ oxidation is uncertain due to the potential variability in oxidant demand and the inability to effectively distribute the oxidant uniformly throughout the aquifer. A pilot test of the technology would be required to evaluate these factors. Over the longer term, the level of effectiveness of the groundwater extraction and SVE components would tend to degrade without ongoing operations and maintenance activities. As with Alternatives 6 and 7, the effects of the in situ oxidation on the ongoing biodegradation are uncertain, and this uncertainty reduces the overall reliability of this alternative.

Reduction of Toxicity, Mobility, or Volume. Alternative 10 significantly reduces the mobility of contaminants in the groundwater plume by controlling off-site migration at the north and south ends of the site and by controlling migration of contaminated groundwater and soil vapors from the source area.

Alternative 10 also has the potential to significantly reduce contaminant volume (i.e., mass) in the source area through a combination of in situ oxidation, groundwater

extraction, and SVE. Once full scale implementation of the in situ oxidation begins, mass removal rates for the combined source area treatment (oxidation, groundwater extraction, and expanded SVE system) is estimated to start at 90,000 lbs/yr during the first year of operation and drop to approximately 50,000 lbs/yr after year 5 of treatment. Over the first five years of scale operation (i.e., through 2010), Alternative 10 would remove an estimated 160,000 lbs of VOCs. Over 30 years, Alternative 10 would remove an estimated 420,000 lbs to 450,000 of VOCs, or 90 to 95 percent of the total estimated contaminant mass (see Appendix B).

As noted above, the estimated mass removal rates are based on a number of assumptions regarding contaminant mass present, effectiveness of remedial technologies, and implementability. For Alternative 10 in particular, the implementability issues are severe enough (see discussion below) that actual mass removal rates could be significantly lower. These estimates should be used for comparative purposes only.

Short-Term Effectiveness. Alternative 10 provides a moderate to high level of risk reduction in the short-term. Potential off-site receptors (i.e., office workers, trench workers) would be protected as off-site VOC concentrations continue to decline due to ongoing operation of the groundwater ICM. In addition, potential risks to on-site office workers would be reduced by declining groundwater concentrations in the vicinity of the office building from operation of the ICM. These potential risks to on-site indoor air quality would be effectively eliminated once the expanded SVE wells adjacent to the office building were operational. Following procedures established in institutional controls would protect on-site trench workers.

There are potentially high implementation risks associated with Alternative 10. The risks associated with the ICM component, source area groundwater extraction system, and SVE systems are as described for Alternative 5. The major risks with this alternative are related to potential reaction between the permanganate and the bulk organic chemicals stored, packaged, and handled at the Univar facility. Based on the existing information, the in situ oxidation of the source area will require delivery, storage, and handling of over 8 million pounds of pure potassium permanganate solids. In order to deliver the permanganate to subsurface, the solid permanganate would have to be mixed with water to create approximately 27,000 gallons of permanganate solution each day for nearly 5 years. Because the area where in situ oxidation would be applied is the same as, or adjacent to, areas of bulk organic chemical storage and handling, there is a potential for an accidental release or spill to bring the strong oxidant and the organic solvents together. The resulting exothermic reaction would create a very dangerous situation for workers in the area and could lead to a catastrophic fire and/or explosion of the bulk solvents.

Another potential short-term risk is the heat generated in the subsurface during injection of the oxidant. It would be very important to avoid elevated temperatures that could damage or destroy subsurface utilities and/or product lines. Such damage could lead to dangerous conditions or to the release of additional contaminants.

Implementability. The implementability of Alternative 10 is low. Implementing in situ oxidation on the scale required at an active chemical distribution facility would be

extremely difficult, and as mentioned above, potentially dangerous. Implementation could require 5 years of nearly continuous chemical oxidant handling and injection in a very active portion of the facility. The inclusion of the oxidant injection wells and piping in the source area will significantly complicate the construction and the need to protect existing chemical storage and handling areas from potential contact with the oxidant would further limit the accessibility to optimal areas for remediation.

Experience, equipment, and services for the groundwater extraction, SVE, and vapor and water treatment systems are readily available and the operation and maintenance of these systems is relatively routine. As mentioned above, however, although the expertise and equipment needed to implement the in situ oxidation is available, implementation at the scale required at an active facility will be very difficult.

Extensive natural attenuation has been documented at the site (Appendix C). The large-scale, sustained injection of a strong oxidant will significantly impact the nature and rate of natural attenuation.

Cost. The total estimated NPV cost for implementation and 30 years of operation of Alternative 10 is approximately \$19,830,000. This includes \$5,060,000 in capital costs and \$14,770,000 in O&M costs (see Table 7-1).

8.2.6 Alternative 11: Groundwater ICM, Expanded SVE, Source Area Groundwater Extraction, Source Area Enhanced In Situ Biodegradation, and Natural Attenuation

Each of the evaluation criteria is presented below with a discussion of how well this alternative meets the criterion.

Long-Term Reliability and Effectiveness. The long-term reliability and effectiveness of Alternative 11 is similar to that of Alternatives 5, 6, and 7, although more uncertain due to the use of enhanced in situ biodegradation. As described in Section 7.6.1, implementation of enhanced in situ biodegradation would only occur when monitoring indicated that the ongoing natural attenuation processes were no longer effectively degrading contaminants at an acceptable rate (assumed to be after 8 years for purposes of the CMS). Once implemented, the enhanced in situ biodegradation would increase mass removal rates potentially to, or in excess of, those previously observed. As with the other alternatives that include more active source treatment, however, this increased mass removal rate would not provide a greater level of protection to potential receptors.

Alternative 11 is expected to operate for at least 30 years, with the enhanced in situ biodegradation component operating on an ongoing basis once started. The reliability and effectiveness of enhanced in situ biodegradation is uncertain due to potential variability in subsurface geochemistry and the inability to effectively distribute additives (e.g., nutrients, co-metabolites) uniformly throughout the aquifer. A pilot test of the technology would be required to evaluate these factors. Over the longer term, the level of

effectiveness of the groundwater extraction and SVE components would tend to degrade without ongoing operations and maintenance activities.

Reduction of Toxicity, Mobility, or Volume. Alternative 11 significantly reduces the mobility of contaminants in the groundwater plume by controlling off-site migration at the north and south ends of the site and by controlling migration of contaminated groundwater and soil vapors from the source area.

Alternative 11 also has the potential to significantly reduce contaminant volume (i.e., mass) in the source area through a combination of enhanced in situ biodegradation, groundwater extraction, and SVE. For purposes of this CMS, it is assumed that mass removal rates for Alternative 11 will be the same as Alternative 5; i.e., the enhanced in situ biodegradation will maintain degradation rates at their current level. As described in Section 8.2.2, Alternative 5 would remove approximately 110,000 lbs of VOCs during the first five years of operation (i.e., through 2010). Over 30 years, Alternative 5 will remove an estimated 281,000 lbs to 381,000 of VOCs, or 60 to 81 percent of the total estimated contaminant mass (see Appendix B).

As noted above, the estimated mass removal rates are based on a number of assumptions regarding contaminant mass present, effectiveness of remedial technologies, and implementability. These estimates should be used for comparative purposes only.

Short-Term Effectiveness. Alternative 11 provides a moderate to high level of risk reduction in the short-term. Potential off-site receptors (i.e., office workers, trench workers) would be protected as off-site VOC concentrations continue to decline due to the ongoing operation of the groundwater ICM. In addition, potential risks to on-site office workers would be reduced by declining groundwater concentrations in the vicinity of the office building resulting from ICM operation. These potential risks to on-site indoor air quality would be effectively eliminated once the expanded SVE wells adjacent to the office building were operational. Following procedures established in institutional controls would protect on-site trench workers.

The implementation risks associated with Alternative 11 are relatively low. The ICM component only includes a limited amount of intrusive work (e.g., trenching, well installation). As with Alternative 5, installation of the source area remediation systems will involve intrusive work in areas of high contamination, buried utilities and chemical transfer piping, and ongoing operations. Potential risks associated with this work in the source area can be mitigated through careful system design, development and implementation of health and safety procedures, and close coordination with Univar operations. The handling and injection of additives for the enhanced in situ biodegradation pose a low risk. VOC emissions from the treatment system represent a potential risk to nearby workers. The treatment system is designed to minimize this potential risk. If this alternative is recommended for implementation, these potential risks will be quantified in Section 9 to ensure that the treatment system is adequate to protect nearby workers. Also as with Alternative 5, there is limited potential for settlement due to lowering of the water table once operation of the source area

groundwater system begins. This potential risk can be mitigated through careful design of the extraction system and monitoring of water levels during system operation.

Implementability. In general, the implementability of Alternative 11 is similar to that of Alternative 5 (see discussion above). The inclusion of the additive injection wells and piping in the source area will further complicate the installation, but these difficulties can likely be overcome through careful design, planning, and coordination with the facility during construction.

Experience, equipment, and services for the in situ biodegradation, groundwater extraction, SVE, and vapor and water treatment systems are readily available. The equipment required for implementation and treatment of contaminated media is reliable and the operation and maintenance is relatively routine. Maintenance of the additive injection, groundwater extraction, and SVE systems located in the source will be more difficult due to the ongoing facility operations in this area. Treated groundwater will be discharged to the storm sewer adjacent to the treatment building under the existing NPDES permit already in place for the facility.

Cost. The total estimated NPV cost for implementation and 30 years of operation of Alternative 11 is approximately \$9,680,000. This includes \$4,260,000 in capital costs and \$5,420,000 in O&M costs (see Table 7-1).

8.3 Comparative Evaluation of Remedial Action Alternatives

In this section, the CAAs are compared against each other for the RCRA performance standards and each the evaluation criteria defined in Section 8.1.2. The comparative analysis of alternatives is summarized in Figure 8-1.

8.3.1 RCRA Performance Standards

As described earlier in this section, the CAOs for the site defined in Section 4.4 address the three RCRA performance standards: (1) protect human health, (2) attain media cleanup objectives and (3) remediate source areas. The evaluation of the CAAs against the RCRA performance standards is documented in Table 6-2 under the “effectiveness” column. A brief comparison of the retained alternatives for the three performance standards is provided below. A more detailed analysis documenting compliance with each CAO will be performed for the recommended alternative in Section 9.

As can be seen, Alternative 1 is rated as having a low effectiveness because, although it does provide a moderate level of protection to human health, it does little to achieve media cleanup objectives and essentially nothing to remediate the source area.

The remaining CAAs are rated as having medium to high effectiveness (except Alternative 7, which is rated high). All of these alternatives provide a high level of protection to potential on-site and off-site receptors through implementation of the groundwater ICM and the expanded SVE system and should also produce significant

reductions in contaminant concentrations, especially off-site and in areas downgradient of the source area containment/treatment systems.

The remaining CAAs all meet the source remediation standard in that they “reduce or eliminate further releases that might pose threats.” The degree to which each CAA remediates the source area varies; see the “reduction in toxicity, mobility, or volume” balancing criteria below for a quantitative discussion of how much source treatment each alternative achieves.

8.3.2 Long-Term Effectiveness and Reliability

All of the alternatives, through operation of the groundwater ICM, will effectively and reliably control off-site contaminant migration along the northern and southern ends of the facility and be protective of potential off-site receptors. With respect to potential on-site receptors (indoor office workers), all of the alternatives with the exception of Alternative 1 provide a high level of protection, primarily through construction and operation of the expanded source area groundwater extraction and SVE systems.

Alternatives 6, 7, 10, and 11 include additional source area treatment components that will remove varying amounts of contaminant mass over different periods of time (see Section 8.3.2 for discussion). Because the other components of these alternatives already provide a high level of protection to potential receptors, the increased mass removal rates of these four alternatives would not, however, translate into a measurable increase in protectiveness for either on- or off-site receptors.

The reliability of the alternatives are generally similar, with the possible exceptions of the source treatment technologies for Alternative 7 (steam sparging) and Alternative 10 (in situ oxidation). Although both of these technologies are reliable in theory, their application at this site would require pilot testing to determine effectiveness and design parameters, and both technologies are very operationally complex and the ability to reliably operate them at an active distribution facility is uncertain (see Section 8.3.4).

8.3.3 Reduction in Toxicity, Mobility, and Volume

All of the alternatives significantly reduce the mobility of contaminants at the north and south ends of the site through implementation of the groundwater ICM. With the exception of Alternative 1, all of the alternatives also effectively reduce the mobility of contaminants in the source area through implementation of the expanded source area SVE and source area groundwater extraction. The additional source treatment components of Alternatives 6, 7, 10, and 11 do not significantly improve the reduction in mobility.

In contrast to the roughly equivalent reductions in mobility provided by the alternatives, the reductions in contaminant volume (i.e., mass) and toxicity vary significantly from one alternative to the next. Table 8-1 summarizes the estimated mass removal rates in the short (5 years) and long (30 years) terms. In the short-term, Alternative 1 only removes

an estimated 4 percent of the contaminants through operation of the groundwater ICM. Alternatives 5 and 11 remove and estimated 23 percent of contaminants within 5 years, the vast majority of this removal resulting from implementation of the source area SVE and groundwater extraction system. Alternative 6 provides an additional 9 percent short-term mass removal through implementation of source area air sparging. Alternative 10 is estimated to provide an additional 2 percent of mass removal compared to Alternative 6, although this estimate is quite uncertain and depends on the results of a pilot study and the ability to implement the in situ oxidation technology. Finally, Alternative 7 provides the most mass removal through implementation of steam sparging, removing an estimated 57 percent of the total contaminant mass with 5 years of operation.

In the long-term, Alternative 1 is estimated to remove 22 to 24 percent of the contaminant mass, approximately 30 percent of this through operation of the groundwater ICM and 75 percent through natural attenuation. Alternatives 5, 6, and 11 all provide approximately triple the long-term mass removal of Alternative 1, the increase almost exclusively attributable to the source area groundwater extraction and expanded SVE components of these alternatives. It is interesting to note that the increased short-term mass removal rate of Alternative 6 is estimated to be off-set in the longer term by reduced rates of natural attenuation. Alternatives 7 and 10 are both estimated to remove 90 to 95 percent of the contaminant mass through very aggressive source treatment using steam sparging and in situ oxidation, respectively.

As noted above, the estimated mass removal rates are based on a number of assumptions regarding contaminant mass present, effectiveness of remedial technologies, and implementability. The effect implementability may have on mass removal rates is of most concern for the source treatment alternatives with the most complicated technologies (i.e., Alternatives 7 and 10); actual mass removal rates could be significantly lower for these alternatives.

8.3.4 Short-Term Effectiveness

There are two primary aspects to the short-term effectiveness criteria: (1) short-term reductions in risk to potential receptors and (2) risks associated with implementation of an alternative. These two factors are discussed separately below.

Short-Term Risk Reduction. With the potential exception of Alternative 1, all of the alternatives provide moderate to high levels of short-term risk reduction. Potential off-site receptors (i.e., office workers, trench workers) would be protected as off-site VOC concentrations decline after the groundwater ICM starts up. Potential risks to on-site office workers would be reduced shortly after ICM startup by declining groundwater concentrations in the vicinity of the office building. These potential risks to on-site indoor air quality would be effectively eliminated once the expanded SVE wells adjacent to the office building were operational. Following procedures established in institutional controls would protect on-site trench workers. As noted in Section 8.3.1, the additional source treatment components of Alternatives 6, 7, 10, and 11 do not provide increased risk reduction in the short-term.

Implementation Risk. The implementation risks for the alternatives vary widely. Alternative 1 has a very low implementation risk associated with the groundwater ICM; the main component of the implementation risk is residual VOC emissions from the ICM treatment system. The implementation risk for Alternative 5 is somewhat higher than Alternative 1 due to the intrusive work required to install the source area groundwater and SVE systems. These risks can be readily mitigated through careful planning and construction, however, and the overall implementation risk for Alternative 5 is relatively low. The implementation risks for Alternative 6 are very similar to those of Alternative 5, with only a small increase in the amount of intrusive work involved. For Alternatives 5 and 6, the risk associated with air emissions is potentially higher than Alternative 1 due to the higher VOC concentrations expected as a result of source area treatment.

There are moderate implementation risks associated with Alternative 7. There are additional intrusive activities compared to Alternatives 5 and 6, and there is the potential for elevated temperatures to damage or destroy subsurface utilities and/or product lines during operation of the steam sparging system. Such damage, which can likely be controlled through careful operational practices and monitoring, could lead to dangerous conditions or to the release of additional contaminants. Potential air emission risks for Alternative 7 are also somewhat higher due to the very high VOC levels expected to be generated by the steam system. Finally, there is the potential for injury to onsite workers due to high temperature, above ground piping.

Alternative 10 potentially has high implementation risks, with the major risk being the potential reaction between the permanganate and the bulk organic chemicals stored, packaged, and handled at the Univar facility. As described in Section 8.2.5, implementing this alternative would require delivery, storage, and handling of very large quantities of potassium permanganate solids, and blending approximately 27,000 gallons of permanganate solution each day for nearly 5 years. These permanganate-handling activities would occur in close proximity to areas of bulk organic chemical storage and handling. In the event of an accidental release or spill of either permanganate and/or solvent, the resulting reaction would create a very dangerous situation for workers in the area and could lead to a catastrophic fire and/or explosion of the bulk solvents. Another potential short-term risk associated with Alternative 10 is the heat generated in the subsurface during injection of the oxidant, which could result in elevated temperatures that could damage or destroy subsurface utilities and/or product lines. Such damage could lead to dangerous conditions or to the release of additional contaminants.

The implementation risks for Alternative 11 are relatively low and very similar to Alternatives 5 and 6.

8.3.5 Implementability

The groundwater ICM has already been implemented; therefore, the evaluation of this criterion will focus on the source area components of the alternatives. For all the alternatives that include source area actions, construction in the source area will be

significantly complicated by existing facility operations and facility structures on the loading dock and between the railroad spur and the solvent tank farm (see Figure 5-1). Constructing a remediation system in these areas will provide significant challenges with respect to protecting existing structures and installing wells and piping in locations optimal for remediation. The degree to which these difficulties can be overcome for each alternative is discussed below.

The source area groundwater extraction and SVE systems in Alternative 5 would be moderately difficult to implement. Given the expected radius of influence of the SVE wells and groundwater extraction wells, there will be some flexibility in well placement that will make installation somewhat easier. The conveyance and vacuum piping for these systems will require careful layout, but should be manageable. The air sparging wells and piping included in Alternative 6 will slightly increase the difficulty of installation, although some of the locations and piping runs can be combined.

Alternative 7 would, in general, be difficult to implement. Constructing the steam sparging system will require two separate and significant construction phases (pilot study and full-scale systems) and the inclusion of the steam sparging wells and piping in the source area will significantly complicate the construction and the need to protect existing facility utilities and product lines would further limit the accessibility to optimal areas for remediation. If facility utilities or product lines needed to be relocated in order to implement Alternative 7, the implementability of this alternative would be reduced further.

Alternative 10 would be very difficult to implement and as mentioned above, potentially dangerous. Implementation could require 5 years of nearly continuous chemical oxidant handling and injection in a very active portion of the facility. The inclusion of the oxidant injection wells and piping in the source area will significantly complicate the construction and the need to protect existing chemical storage and handling areas from potential contact with the oxidant would further limit the accessibility to optimal areas for remediation.

The implementability of Alternative 11 would be very similar to Alternative 5 or 6.

8.3.6 Cost

The evaluation of the reasonableness of cost considers the following specific factors:

- The total NPV cost of the CAA (capital costs, recurring costs, and future costs);
- The degree to which the costs of the remedial action are proportionate to the benefits to human health and the environment created through risk reduction or risk management;
- The degree to which the costs are proportionate to the benefits created through restoration or protection of existing and reasonably likely future beneficial uses of land and water; and

- Degree of sensitivity and uncertainty of the costs.

Each of these factors is discussed separately below

Total Cost. The costs of the CAAs are summarized on Table 7-1. Alternative 1 is the least expensive, with total NPV costs of approximately \$6,980,000. Alternative 5 is the next most expensive alternative at \$8,840,000, or 27 percent more than Alternative 1. Alternatives 6 and 11 have similar costs of approximately \$9,700,000, and are the next most expensive CAAs and cost roughly 10 percent more than Alternative 5.

Alternatives 7 and 10 are by far the most expensive alternatives at \$13,500,000 and \$19,830,000, respectively. These costs are 1.5 and 2.3 times the cost of Alternative 5.

Cost Proportionate to Risk Reduction. The CAOs for the site (Section 4.4) define the nature of the potential risks posed by site contaminants. Because no environmental receptors were identified, this evaluation will focus on the benefits to human health created through risk reduction. All of the alternatives address potential off-site risks by implementation of the groundwater ICM. Therefore, the costs related to addressing potential off-site risks are the same and proportionate with the risk reduction achieved.

As discussed in Section 8.3.1, all of the alternatives (except Alternative 1) provide a high level of protection for potential on-site receptors (indoor office workers), primarily through construction and operation of the expanded source area groundwater extraction and SVE systems (Alternative 5). Although Alternatives 6, 7, 10, and 11 include additional source area treatment components that will remove varying amounts of contaminant mass over different periods of time (Section 8.3.2), this increased mass removal does not provide additional benefits through risk reduction for on-site (or off-site) receptors. Therefore, the additional costs associated with these actions are not proportionate to the benefits (or lack thereof) provided.

Cost Proportionate to Restored Beneficial Uses. The current contamination at the site does not reduce the existing or reasonably likely future uses of the land as an active chemical distribution facility in the heavily industrialized northwest Portland area. As a result, the evaluation of this factor will focus on the potential to restore or protect beneficial uses of groundwater. The groundwater beneficial use evaluation conducted by Univar is summarized in Section 2.4.3. Based on this analysis, there are no current or reasonably likely future uses of groundwater in the vicinity of the site. Because these are no beneficial uses to restore, the additional costs associated with the source treatment technologies in Alternatives 5, 6, 7, 10, and 11 are disproportionate to the benefit achieved.

Cost Uncertainty and Sensitivity. The construction and annual O&M costs for Alternative 1 (i.e., groundwater ICM) are either known or reasonably certain. The construction costs of the source area groundwater extraction and SVE system for Alternative 5 are also fairly certain, although there is some uncertainty due to potential difficulties in installing systems in the more active portions of the source area. There is

also some uncertainty in the O&M costs for Alternative 5 because the required groundwater extraction rate and contaminant mass removal rates are not known.

The uncertainty associated with the costs for Alternative 6 are somewhat higher than Alternative 5 due to the addition of the air sparging system. The major sensitivity with Alternative 6 costs is the length of time the sparging system will be operated; depending on the performance of the system, the actual time period (and cost) could be higher or lower than estimated.

There is significant uncertainty and sensitivity to the estimated cost of Alternative 7. The cost of constructing the steam sparging system will depend on the results of the pilot test and the cost of overcoming the difficulties associated with constructing a high temperature steam system within the active portion of the facility. The O&M costs are highly dependent on, among other items, the required quantity of steam needed to achieve effective treatment, the cost of the fuel needed to generate the steam, and length of time the steam sparging system will be operated.

The cost for implementing and operating Alternative 10, assuming it can be implemented at all, are very uncertain and sensitive to factors that will not be known with any certainty until after completing a pilot test. Nearly \$9,000,000 of the total cost of this alternative is associated with the purchase, blending, and injection of the potassium permanganate. The actual permanganate requirements are very sensitive to contaminant amounts and distribution as well as the natural oxidant demand of the soil and groundwater.

The uncertainty and sensitivity of the costs for Alternative 11 are similar to Alternative 6. The most significant factors that could effect Alternative 11 costs are the timing of when additives would be required, the cost of the additives (unknown at this time), and the duration such addition would be required.

9 RECOMMENDED CORRECTIVE ACTION ALTERNATIVE

The detailed evaluation of the CAAs presented in Section 8, including the comparative evaluation presented in Section 8.3, provides the basis for selecting a preferred CAA for implementation at the Univar site. The detailed evaluation is summarized below followed by the recommendation of the preferred CAA. Finally, this section provides an overview of how the preferred CAA would be implemented.

9.1 Summary of Detailed Analysis of CAAs

The detailed analysis of alternatives is summarized in Figure 8-1 and discussed below for the RCRA performance standards and each of the evaluation criteria.

9.1.1 RCRA Performance Standards

As can be seen in Figure 8-1, Alternative 7 provides the best performance relative to the RCRA performance standards, primarily due to the aggressive mass removal that could be expected. Alternatives 5, 6, and 11 meet the RCRA performance standards to a slightly lower degree, although as noted earlier, they still provide a high level of performance. Alternative 10 is slightly lower yet, because, even though the potential for very high levels of mass removal exists in theory, the severe implementability and implementation risk problems lessen the likelihood that the highest level of treatment could be achieved with this technology. Lowest performing of all is Alternative 1, which although it does protect human health, does little to treat the source area and stands little chance of attaining media standards over much of the site.

The most important conclusion of the detailed evaluation is that, with the exception of Alternative 1, all of the alternatives perform at a high level against the following two RCRA performance standards:

- **Protect human health** – The alternatives provide a high level of protection to potential on-site and off-site receptors through implementation of the groundwater ICM and the expanded SVE system.
- **Remediate source areas** – All the alternatives significantly reduce mobility and, although the amount of mass removal varies between the alternatives, they all provide significant mass removal in the source area.

By substantially meeting these criteria, all of the alternatives (except Alternative 1) meet all of the CAOs for the site defined in Section 4.4. Balancing Criteria

Table 8-1 also summarizes the evaluation of the alternatives against the following balancing criteria:

- Long-term Reliability and Effectiveness;
- Reduction of Toxicity, Mobility, or Volume;
- Short-term Effectiveness;
- Implementability; and
- Cost.

Although Alternative 1 is rated as best for the implementability and cost criteria, it ranks by far the worst against the long-term effectiveness and reduction in toxicity, mobility, and volume criteria. As a result, and because it does not substantially achieve the RCRA performance standards, Alternative 1 will not be considered for implementation as the final CAA and will not be discussed further in this section.

For the remaining alternatives, all perform very well against the long-term effectiveness criteria by providing long-term and reliable protection of human health and the environment. Similarly, the remaining alternatives all perform well against the reduction in toxicity, mobility, and volume criteria. Alternatives 7 and 10 have the potential, at least in theory, to remove more contaminant mass than alternatives 5, 6, and 11 and are therefore rated slightly better.

Unlike the first two criteria, there are significant differences between the alternatives with respect to the remaining three criteria: short-term effectiveness, implementability, and cost. Alternatives 5, 6, and 11 are rated the same and best for short-term effectiveness, while Alternative 7 and especially Alternative 10 are rated much lower due to the significant implementation risks associated with these two alternatives.

Alternatives 5, 6, and 11 are also rated as having similar and moderate implementability, while alternatives 7 and 10 are rated much lower due to the numerous implementation problems. In the case of Alternative 10, these problems are so severe that this alternative is not considered implementable given the assumptions regarding the source area size and contaminant mass present.

Regarding cost, Alternative 5 is rated best for the cost because it provides a high level of risk reduction and source control at the lowest cost of the remaining alternatives. Alternatives 6 and 11 are slightly less cost effective than Alternative 5 due to the increased cost of their approach to source treatment without the added benefit of increased protectiveness. Finally, alternatives 7 and 10 are rated the lowest for cost due to the very high costs.

It should be noted once again, that there are significant uncertainties associated with the development and subsequent evaluation of the CAAs in Sections 7 and 8. Most notable of these assumptions are the definition of the source area (Section 2.5.3) and the estimate

of the contaminant mass present within the source area (Section 2.5.4 and Appendix B). If the actual nature and extent of the source area is significantly different from that assumed in this report, the evaluation of the retained alternatives could change significantly as well. For example, if the actual source area were much less extensive and/or contained much less contaminant mass, some of the severe drawbacks of alternatives 7 and 10 (e.g., implementability, cost, short-term effectiveness) would be lessened. Conversely, if the actual contaminant mass were higher than estimated, these same drawbacks would be exacerbated. These uncertainties, and the effect they may have on applicability of certain alternatives, will be taken into account when recommending a preferred CAA for implementation.

9.2 Recommendation of Preferred Corrective Action Alternative

Based on the evaluation summarized in Section 9.1, Univar recommends that the preferred CAA for the site be a phased corrective action, with the initial phase being the implementation of Alternative 5. Subsequent phases of the corrective action will include a source area investigation and treatability studies (see Section 9.3 below for details). Based on the results of the source area investigation and treatability studies, and the performance of Alternative 5 over several years of operation, additional corrective actions will be evaluated for potential implementation in the source area.

This preferred corrective action approach:

- Meets the RCRA performance standards and the CAOs;
- Is effective in both the short and long terms;
- Controls the migration of contaminants from the source area;
- Provides significant mass reduction over time;
- Is implementable; and
- Is cost-effective.

Table 9-1 documents the ability of Alternative 5 to meet the site-specific CAOs.

This recommended approach to the corrective action is based on certain assumptions, especially those related to the nature and extent of the source area. Additional data collection and evaluation can significantly reduce the uncertainties associated with these assumptions. This data collection should not, however, delay implementation of the first phase of the corrective action (i.e., Alternative 5) as such a delay would defer the protectiveness and other benefits provided by this alternative. The manner in which the additional data collection and evaluation will be conducted is outlined in Section 9.3.

In Section 8, implementation risk related to air emissions associated with each CAA was qualitatively evaluated, and a quantitative risk evaluation was deferred to this section for

the preferred CAA. Appendix G summarizes the results and methods used to evaluate risks associated with implementing the preferred CAA described in this section. Specifically, the risk to workers from exposure to air emissions from the vapor treatment system that treats the combined emissions from the groundwater extraction and soil vapor extraction systems included in the preferred CAA were estimated.

Briefly, the potential risk associated with treatment system air emissions was estimated for two scenarios: one based on the design VOC removal rate of 95 percent and one based on the actual removal rates observed during initial ICM operation. In each scenario, the estimated VOC concentration in the treatment system stack emissions and a ground-level exposure concentration were estimated using an EPA-approved air dispersion model (SCREEN3). Potential worker risk was estimated using these modeled exposure concentrations and standard risk evaluation procedures.

As described in detail in Appendix G, the total carcinogenic risk for both scenarios is approximately 1.1×10^{-5} . The hazard index (HI) for the flat 95 percent removal efficiency is 0.16 and is 0.61 using the actual ICM treatment efficiencies. The cancer risk does not change between scenarios because trichloroethene is responsible for over 90% of the total cancer risk and the treatment efficiency is the same for both scenarios (i.e., 95 percent). The HI increases by a factor of nearly 4, although the HI is still well below the threshold of 1. The HI increased because the ICM treatment efficiencies for a number of the noncarcinogenic compounds is much lower than the flat 95%.

9.3 Implementation of Preferred Corrective Action Alternative

The final selection and implementation of the preferred corrective action approach would include the following steps that would generally occur in the order listed:

- Finalize CMS and solicit public and state input on the selection (see Section 10);
- Prepare a statement of basis for the selected alternative and finalize the amendment to 3008(h) administrative order on consent (AOC), including the associated scope of work;
- Prepare the Corrective Measures Implementation (CMI) Work Plan. The CMI Work Plan will describe the documents that will be prepared and the activities that will be performed during the implementation of the preferred alternative. Major components of the CMI Work Plan will include the following:
 - A description of the corrective measure design process. This process will likely include a conceptual design that describes the general content and scope of the corrective action and final design that delineates the detailed process, mechanical, electrical, and control systems of the corrective action. The level of detail included in the final design will, in part, depend on how Univar chooses to construct systems (e.g., design-build, bid out to contractors);

- A scope of work for a source area investigation. This investigation would focus on better delineation of the extent of the source area and refining the estimate of mass of contaminants present. The source area investigation would be implemented during installation of the groundwater extraction and/or SVE extraction wells to minimize costs and disruptions at the facility. Specific information that may be obtained during this investigation would, at a minimum, include VOC concentrations in saturated soil, unsaturated soil, and groundwater; and
 - A scope of work for treatability studies and data collection requirements. In order to better evaluate specific technologies (e.g., enhanced in situ bioremediation), additional data would need to be collected and bench or pilot level treatability studies conducted. To the extent possible, data collection for treatability purposes will be conducted as part of the source area investigation described above.
- Following agency approval and public comment of the corrective action design, initiate construction of the alternative and conduct the source area investigation as described above;
 - Begin operations and maintenance of the expanded groundwater extraction and SVE systems; and
 - Conduct treatability studies as needed and defined in the treatability study work plan to evaluate what, if any, additional technologies may be applicable or appropriate in the source area based on the refined definition of the source area.

After the above steps have been completed, it is assumed that several years of routine system O&M monitoring would ensue. What, if any, additional actions would occur after these initial years of O&M would be based on several factors including the performance of the source area treatment systems and the results of the natural attenuation monitoring, source area investigation, and treatability study(ies) conducted.

10 PUBLIC INVOLVEMENT PLAN

Public involvement during the selection and implementation of the preferred CAA will be closely coordinated with EPA and will, in general, follow the procedures outlined in the Community Relations Plan (Revision 1) for the Univar facility (IT Corporation, 2001f). General steps to be taken to keep the public involved in the decision-making process and up to date on the actions being taken include:

- Maintenance of document repositories where the public can review key project-related documents and information;
- Preparation of fact sheets at important points of the corrective action selection, implementation, and operation process. These fact sheets may solicit input from interested parties on certain aspects of the project;
- Conduct public meetings where interested members of the community can receive information on the corrective action process and ask questions; and
- Provide 30-day public comment periods for key documents including the CMS report and statement of basis. A responsiveness summary will be prepared documenting the public comments and questions as well as EPA and Univar's responses.

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TABLES

All of the following are located in seperate files

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TIME TREND PLOTS AND ISOCONCENTRATION MAPS

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SOURCE AREA CONTAMINANT MASS ESTIMATION

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